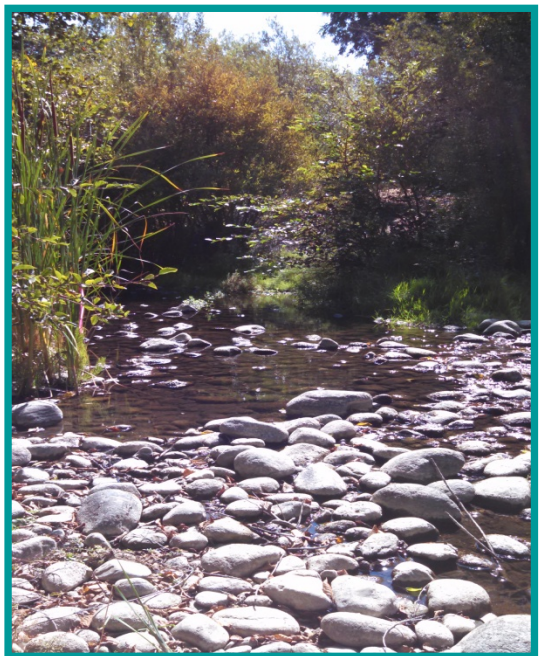

Central Coast Watershed Studies

CCoWS

Comparison of LiDAR and ground based measurements to assess LiDAR accuracy near the Carmel River in Monterey County, California

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Executive Summary

The purpose of this report is to provide an assessment of a 3-meter resolution digital elevation model (DEM) derived from LiDAR (Light Detection and Ranging) data collected by Digital Mapping Inc. (DMI) in 2010 for the Central Coast region. We conducted a broad scale analysis of DMI's checkpoints to assess the vertical accuracy of the LiDAR derived DEM in five land cover classes: shrub, forest, grassland, open/cropland, and urban. Additionally, we conducted a focused comparison of the LiDAR data along the Carmel River riparian corridor. Within the focus area we compared GPS control points and total station transect points, which were collected in 2013 and 2014, to the 3 m LiDAR DEM. The control points were collected using OPUS-corrected, long static GPS occupation, and the transect points were collected using a 3-arcsecond total station along cross-sections in the Carmel River, where the total station surveys were opened and closed on a subset of GPS control points. We applied a non-parametric approach outlined by Aguilar and Mills (2008) to estimate the RMSE values at 95% confidence interval and the expected vertical error for 60 GPS control points and 984 total station transect points. The transect points were averaged to 404 points to account for pixel sub-sampling. The vertical error for GPS (-0.05 m – 3.50 m) and for transects (0.48 m – 4.50 m) at 95% confidence interval differed significantly from DMI's error calculation of 0.4 m (1.2 ft). This difference is mostly due to the distribution of DMI's own control points, which were focused in areas of open terrain. Data processing errors and LiDAR limitation in assessing elevations in thickly vegetated regions or water bodies may have contributed to this difference.

We also mapped DMI's control points and determined the number of points within each of five different land cover types, as well as the percentage of land area

within each land cover type within the study area. We found that the majority of these points were within the open/cropland land cover classification.

While we found a positive bias within the data for the Carmel River corridor, we were able to quantify the error that is inherent and unavoidable in DEM's generated from LiDAR data. This information is particularly useful for local resource managers who utilize the LiDAR derived DEM in studies within the Carmel River corridor.

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Disclaimer:
This report primarily represents student work completed within the constraints of a fixed-duration, limited-verification college class setting.

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Table of Contents

1 Introduction

LiDAR (Light Detection and Ranging) is a remote sensing technique used to collect topographic data. LiDAR measurements are made through sensors that emit a high frequency, narrow laser beam towards the Earth's surface and evaluate the time and angle of the reflected light (Young and Ashford, 2006). Continued improvements in LiDAR technology have promoted its use in various environmental applications (Montane and Torres 2006; Cobby et al. 2001) including modeling of cliff erosion (Young and Ashford 2006), predicting manning's n in floodplains (Smith et al. 2004), sediment volume and transport in rivers (Davis et al. 2002), and assessment and design of urban landscapes (Veneziano 2006).

LiDAR is particularly useful in regions where traditional land-based data gathering methods may be limited (Montane and Torres 2006). LiDAR allows expediency, accessibility, and freedom from certain environmental limitations such as time of day, low sun angle, and cloud cover (Veneziano 2006). Because of its wide use across various disciplines, the evaluation of the precision and accuracy of this technology is becoming increasingly important.

In 2010 Digital Mapping Inc. (DMI) obtained LiDAR data for 2740 km^2 of Monterey, Santa Cruz and San Benito County (Map 1). These data were used to develop bare earth elevation datasets for The Association of Monterey Bay Area Governments (AMBAG) for use by local natural resource managers. Intended applications for products derived from LiDAR include hydraulic and hydrologic modeling applications to directly benefit research in oceanography, agriculture, fluvial and atmospheric sciences.

One such application of the LiDAR derived DEM may be in monitoring physical changes over time in the Carmel River Valley after the planned removal of the San Clemente dam, which is currently (2014) being removed. In the 1990s San Clemente dam was found to be seismically unsafe. The dam has filled almost to capacity with sediment and removal of the dam was determined to be the most effective way to reduce risk, restore the natural flow regime of the river and to re-establish habitat for native aquatic species (MEI 2002, MEI 2005, Capelli 2007). LiDAR-based monitoring was recommended to accurately track channel bed elevations that could lead to flow stage changes following dam removal (ENVS 660 2012).

Similar to other riparian corridors in the central coast, the Carmel River Valley is characterized by a dense canopy. Densely vegetated areas in riparian corridors can result in mis-classifications of LiDAR return points, such that non-ground samples are used to interpolate bare ground. Thus, in forested areas it is typical for LiDAR derived DEMs to overestimate the ground elevation, thereby producing a systematic error.

We present a simple assessment of the LiDAR DEM in the Carmel River Valley using Global Positioning System (GPS) data and total station data collected by California State University Monterey Bay (CSUMB), United States Geologic Survey (USGS) and National Oceanic Atmospheric Administration Southwest Fisheries Science Center (NOAA) to determine the vertical accuracy of the LiDAR DEM. We also analyze the distribution of control points used by the LiDAR data collector (DMI 2010).

1.1 Study Site

The LiDAR data assessed in this study cover 2740 km^2 of the Monterey, Santa Cruz and San Benito Counties (Map 1). The LiDAR coverage is divided into nine blocks to account for variability in terrain height and the irregular shape of the project area (Map 2). The area of focus in the Carmel River Valley is within block three of the nine blocks surveyed (DMI 2010). The area of focus is 200 km^2 that includes the riparian corridor and river channel downstream of San Clemente Dam and the San Clemente Dam Reservoir.

The Carmel River watershed is nestled in the Santa Lucia Mountains of Monterey County and drains approximately 247 km^2 of mountainous and forested terrain to the Pacific Ocean. The upper region of the river (~ 34 km) is sparsely populated and passes through steep terrain (Kondolf and Curry 1986). The lower 24 km of the river is more developed and at increased risk of flooding (Smith et al. 2004).

The region has a Mediterranean climate with moderate temperatures year round. Most rainfall occurs between November and April, with majority (60%) falling between December and February (Kondolf and Curry 1986).

2 Methods

2.1 Assessment of LiDAR Accuracy along the Carmel River

We compared the 2010 LiDAR DEM elevations to control points and total station shots collected along the Carmel River by other workers in 2013 and 2014. The control points were geo-referenced using OPUS-corrected, long static GPS occupation (GPS) and transect point coordinates were shot using a 3-arcsecond Nikon total station (Map 3). CSUMB, NOAA, and USGS collected

control and transect points in 2013 and 2014 along the Carmel River as part of an on-going study to measure potential elevation changes of the river in response to San Clemente Dam removal. The GPS control points were established so that the total station transect points would be shot in a geo-referenced benchmark framework. The GPS control points are located in open areas with minimal canopy. The total station transect points were shot along many cross sections of the Carmel River (Leiker et al. 2014). The total station points are mainly located in areas where vegetation and canopy obscure the channel. In some areas the distance from one transect point to the next was less than resolution of the DEM (3m). For these total station transect points we averaged the known shots within a pixel to develop a single average known value per pixel.

We used ArcMap 10.1 (ESRI 2012) to extract the LiDAR derived DEM pixel values that correspond to each control point and transect point. We calculated the Root Mean Square Error (RMSE) and the 95% confidence interval for the elevation differences between the LiDAR and the known elevations using R 3.0.1 statistical software (R Core Team 2013). We tested the residuals of the elevation differences using a Shapiro - Wilk normality test, which indicated there was significant evidence of non-normality ($p < 6.74 \times 10^{-16}$, $p < 2.2 \times 10^{-16}$) for the control points and the cross section points respectively. Aguilar and Mills (2008) provide a method for calculating the 95% confidence interval that takes skewness and kurtosis into account in determining the RMSE for non-normally distributed residuals. We used the equations described by Aguilar and Mills

(2008) in calculating the 95% confidence interval since there was evidence of non-normality.

2.2 Assessment of Digital Mapping Inc.'s Control Points

We evaluated Digital Mapping Inc.'s (DMI 2010) control points across the entire project area. We assessed the LiDAR DEM in a variety of land cover types by evaluating the distribution of DMI's control points as compared to the land cover types within the LiDAR project area. According to standards developed by the American Society of Photogrammetry and Remote Sensing (ASPRS 2004), a minimum of 20 control points must be collected for each land cover category to determine the vertical accuracy of LiDAR derived DEM in different land cover types. ASPRS (2004) suggests that a common land cover classification scheme be used such as:

- Open/Cropland
- Grassland
- Shrub
- Forest
- Urban

To do this, we mapped each of the coordinates of DMI's 86 control points in ArcMap (ESRI 2012). We then overlaid the control points on a C-CAP regional land cover map provided by NOAA. Finally we reclassified NOAA's land cover categories so they would be consistent with the ASPRS (2004) land cover categories (Table 1, Map 4).

In addition to the 86 control points, DMI evaluated the bare earth data in block three (encompassing the Carmel River focus area) using 29 GPS control

points. These points allowed DMI to test the limits of precision for the LiDAR data in open terrain.

3 Results

3.1 Vertical Accuracy along the Carmel River

A spatial distribution of the 60 GPS control points and the 984 total station transect points are illustrated in Map 3. For the 60 control points, we found the RMSE was 1.29 m, with a 95% confidence interval between 1.06 – 2.33 m. Using the methods derived by Aguilar and Mills (2008) we applied a non-parametric approach and estimated the expected vertical error at the 95% confidence interval to be between -0.05 – 3.50 m. We removed three outliers from the data set because they were taken on the San Clemente Dam spillway, but had up to 18 meter differences in elevation, indicating that those pixels were averaging LiDAR points that were on the spillway, and in adjacent areas of the dam.

For the 984 transect points, which were averaged to 404 points to account for pixel sub-sampling, we estimated an RMSE of 1.54 m, with a 95% confidence interval of the RMSE between 1.46 – 2.31 m. We estimated the expected vertical errors at the 95% confidence interval to be between 0.48 – 4.50 m.

Figure 1 shows the skew in histograms of the residual error

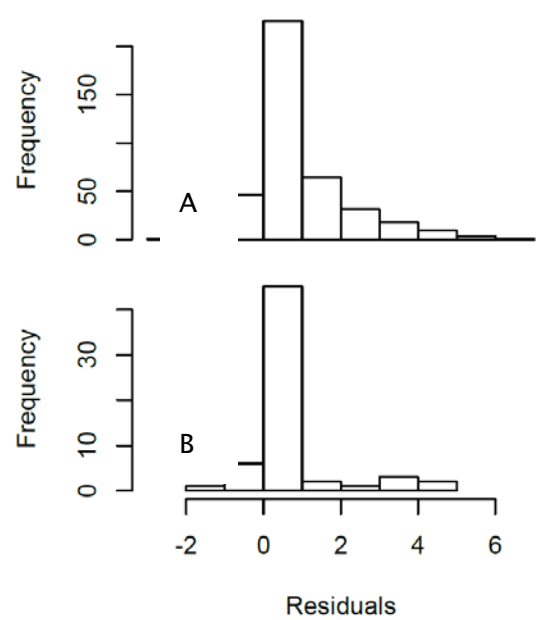

Figure 1: (A) Histogram of transect points residual errors; (B) Histogram of control points residual errors

between the LiDAR derived DEM and known elevations for transect points (Fig 1A) and GPS control points (Fig 1B).

3.2 Digital Mapping Inc.'s Control Points by Land Cover

DMI's (2010) own assessment of their 86 control points showed that the LiDAR accuracy is +/- 1.2 feet (0.40 m) in the vertical at the 95% confidence level for the entire project area. These 86 control points were spatially distributed into the five land cover classes as illustrated in Map 4 and as follows:

- 33 out of the 86 points (38.4%) were classified as open/cropland
- 16 out of 86 (18.6%) - grassland
- 16 out of 86 (18.6%) - urban
- 13 out of 86 (15.1%) - shrub
- 7 out of 86 (8.14%) - forest

In our area of focus along the Carmel River (block 3) there were six DMI control points covering all 5 land cover categories. Only one of these points was in a location classified as forest cover.

The 29 GPS control points in block 3 used by DMI to evaluate the bare earth data are outlined in Map 5. We found that all of these points were collected in the open/cropland cover type. Further mapping showed that all of these points were collected within a rectangle approximately 400 m long and 200 m wide from a single golf course.

Table 1: NOAA C-CAP land cover data reclassified into five land cover types. The number of control stations are the measured control points used by DMI to assess the LiDAR, and the percent of total area is the percentage of area with a specific land cover type for the entire LiDAR study area.

Assessment land cover classification	Number of control stations	Percent of total area	NOAA land cover classification
Urban	16	3.4%	High Intensity developed Medium intensity developed
Open/Cropland	34	27.9%	Low intensity developed Developed open space Cultivated Pasture/Hay Palustrine emergent wetland Estuarine emergent wetland Unconsolidated Shore Bare land
Grassland	16	16.6%	Grassland
Forest	7	35.2%	Deciduous forest Evergreen forest Mixed forest Palustrine forested wetland Estuarine forested wetland
Shrub	13	15.9%	Scrub/shrub Palustrine scrub/shrub wetland Estuarine scrub/shrub wetland

4 Discussion

In our assessment of vertical accuracy we found that the residual errors between the DEM elevations and the control and transect points exhibited a non-normal distribution and a positive skew. These findings are consistent with Aguilar and Mills (2008), who noted that the residuals are likely to be non-normally distributed in areas that are under canopy or vegetation. We propose that the positive bias in the mean of the residuals is due to the nearly ubiquitous vegetation within the Carmel River riparian corridor, which suggests the presence of a systematic error in the LiDAR derived DEM in this area (Aguilar and Mills 2008). The dense canopy and understory shrubs prevent the majority of LiDAR pulses from reaching the bare ground creating a positive bias in the resulting DEM. This error is underrepresented in the DMI error assessment because the majority of their control points are in open or sparsely vegetated areas (Table 1). The location of control points partly accounts for the difference in the DMI reported error and the calculated error for the Carmel River riparian corridor.

There are other factors that may have attributed to the positive bias in the riparian corridor. To produce the DEM, a number of post-processing steps including filtering and gridding are often required and may introduce significant errors (Aguilar and Mills 2008). Filtering involves removing data from pulses that would either introduce noise or unwanted features to the final DEM, like bridges and vegetation. This process could introduce a disproportionate amount of error in the riparian corridor for two reasons: first, the heavy vegetation in the riparian corridor would have a disproportionately high number of points to be filtered. And second, the presence of water in the riparian corridor may also present filtering related errors. To address the presence of water, DMI applied

hydro-flattening, a technique which allows the observer to assume that water bodies such as lakes and rivers are flat across the top. The LiDAR system used by DMI cannot penetrate water at the low intensity of the return points which may lead to miscalculations in elevation (Wang et al. 2014).

Gridding is the process converting the data from LiDAR pulses into a gridded raster format. The 3m resolution of the DEM means that small changes in the horizontal plane can result in large changes in the vertical plane. If the areas around the riparian corridor control points were steeper than the area around the DMI control points, then we would expect greater errors in the riparian corridor.

In both DMI and our accuracy assessment we do not address the horizontal accuracy of the LiDAR derived data. According to Kinzel (2005), horizontal position is difficult to resolve using LiDAR because of discontinuous surface sampling. Additionally, ASPRS (2004) also asserts that horizontal accuracy is difficult to assess and does not require data providers to assess horizontal accuracy, only estimates. Finally, since the LiDAR derived DEM is gridded to 3m, we are limited in our precision. Therefore, only vertical accuracy was assessed.

Of the five land cover types analyzed in the project area, only the open/cropland land cover category was represented by DMI's control points per ASPRS (2004) standards. We found that DMI's accuracy assessment sufficiently meets the requirements to estimate vertical accuracy of the DEM in areas categorized as open or cropland. We also found that the other land cover types: forest, shrub, urban and grassland did not have a minimum of 20 control points. This is of importance to local resource managers who may want to use the LiDAR DEM in land cover types other than open or cropland. For these areas,

we caution that a positive bias may exist that may be greater than the vertical error reported by DMI for the open and cropland land cover category. Finally, in our area of focus along the Carmel River there were six DMI control points, which included at least one point in each of the land cover types.

LiDAR is becoming an increasingly common technology and is extremely beneficial to local resource managers. This assessment suggests that the LiDAR data is useful for large scale, expedient assessments for the region and should be coupled with other photogrammetric techniques or ground-truthing, specifically in land categories other than open/cropland that may have obstructions such as dense vegetation to limit LiDAR penetration. Cobby et al. (2001) applied this approach using algorithms that extracted variance in topographic and vegetation heights relevant to land cover from LiDAR data. A similar approach by Kinzel et al. (2005) was used to predict fluvial geomorphology of the central Platte River in Nebraska. For the Carmel River, DMI LiDAR data may be coupled with land cover specific algorithms and field data to study the impacts of San Clemente dam removal on river morphology, particularly sediment transport (aggradation/degradation) and aquatic habitat indicators such as vegetation that may provide shade. Finally, since the DMI LiDAR data was determined to be sufficient for open/cropland, it may serve as a valuable tool to address local water quality concerns related to intensive agricultural production in the region and help inform future policy goals.

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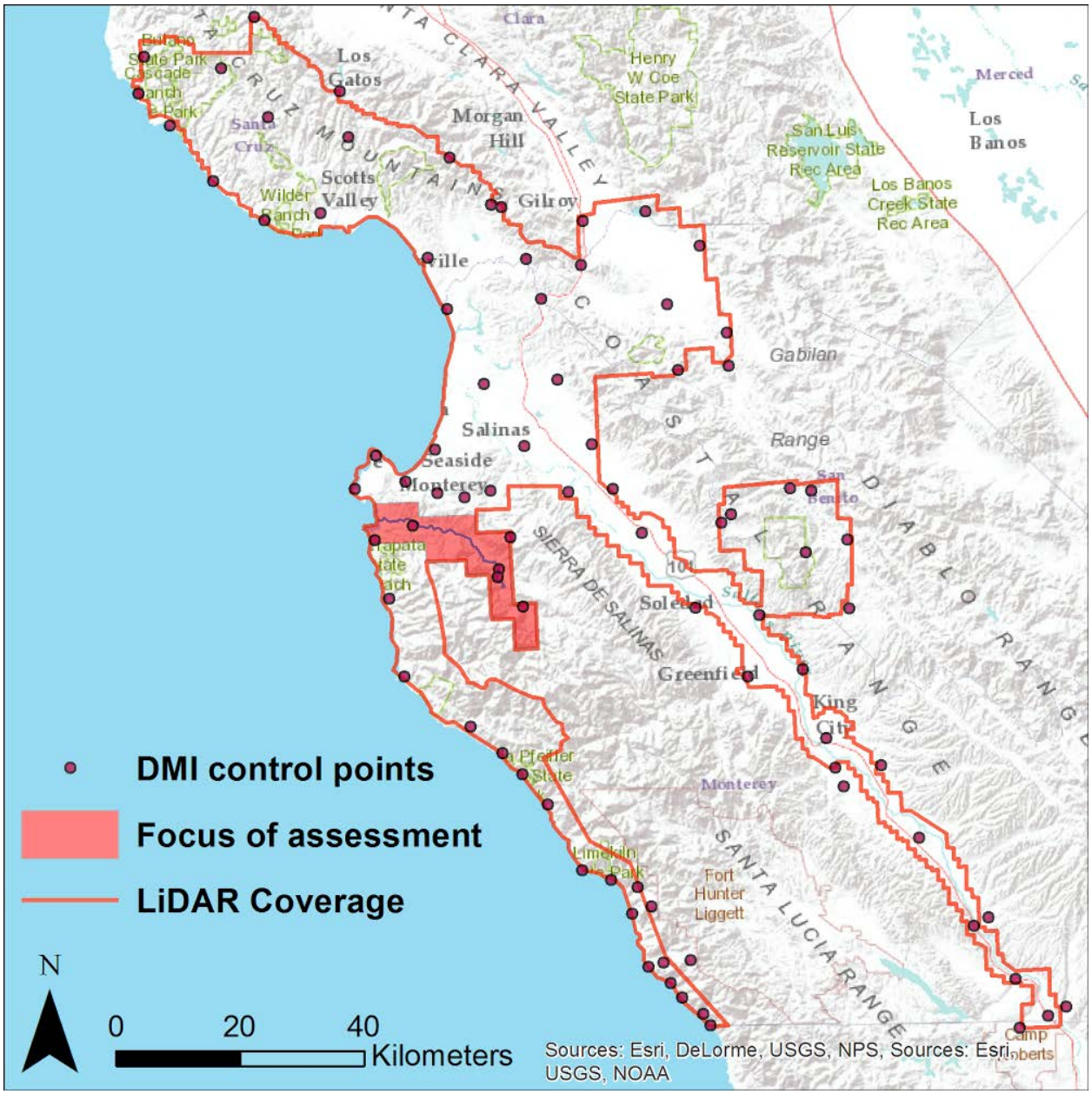
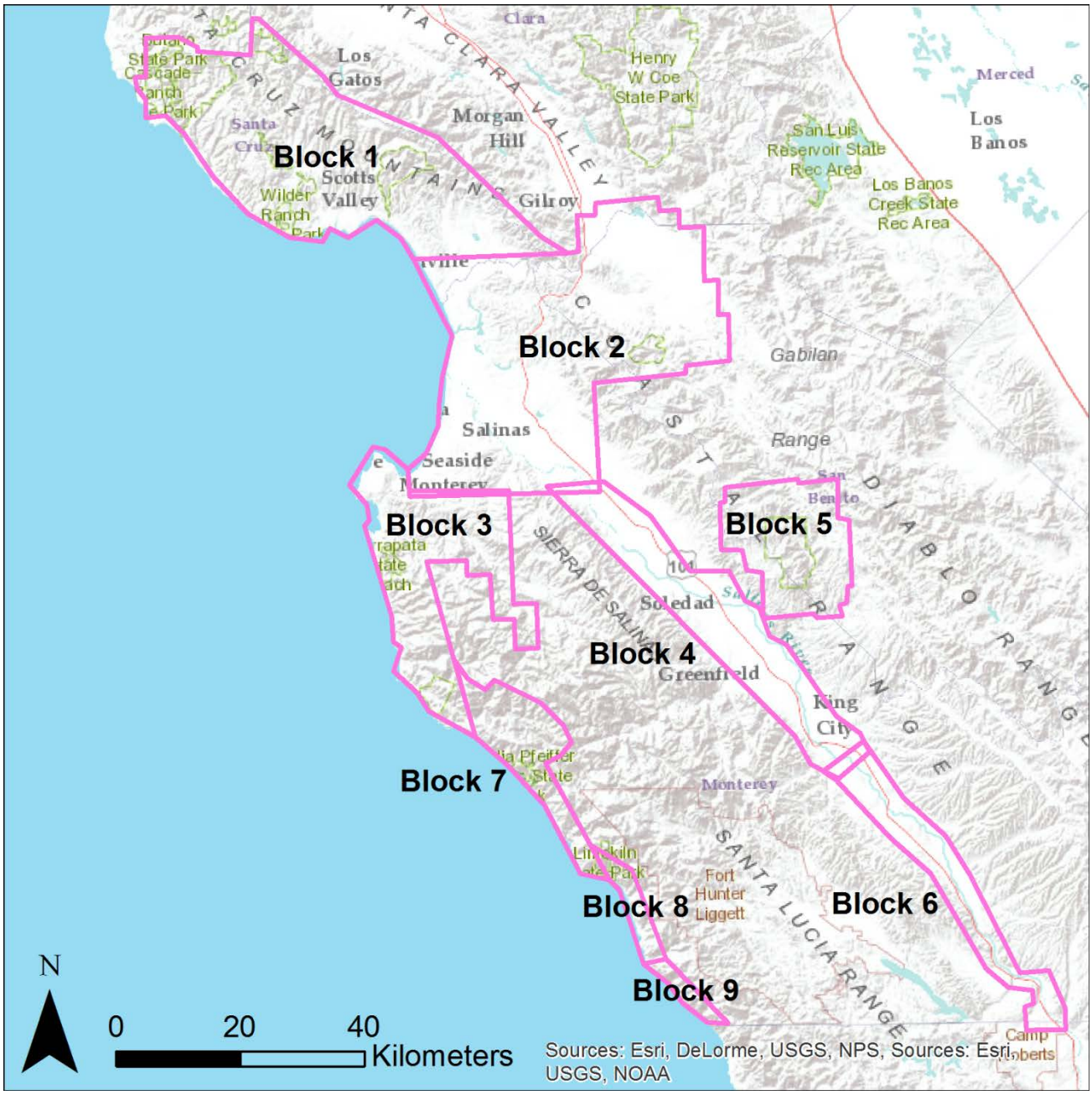
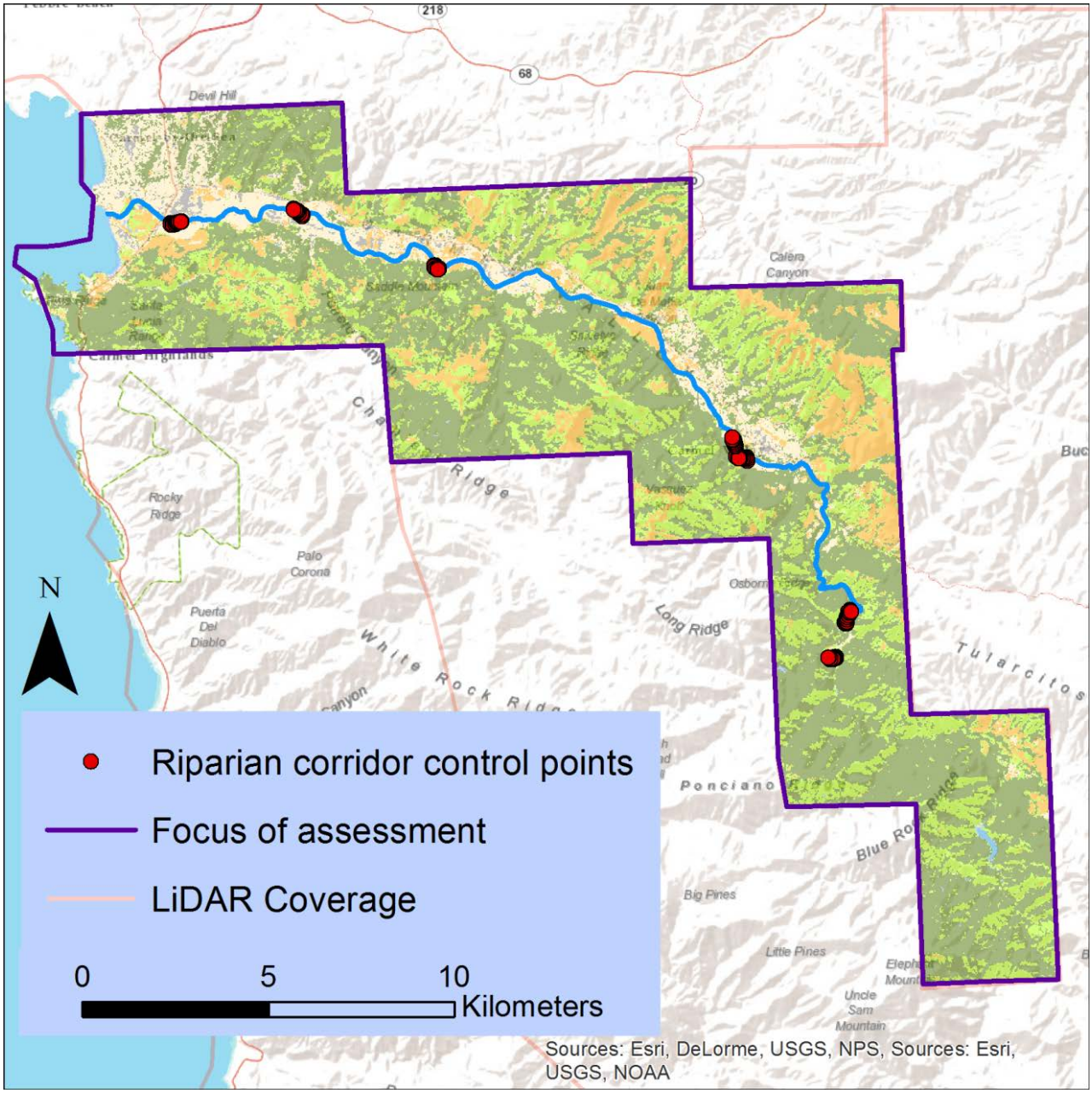
6 Maps



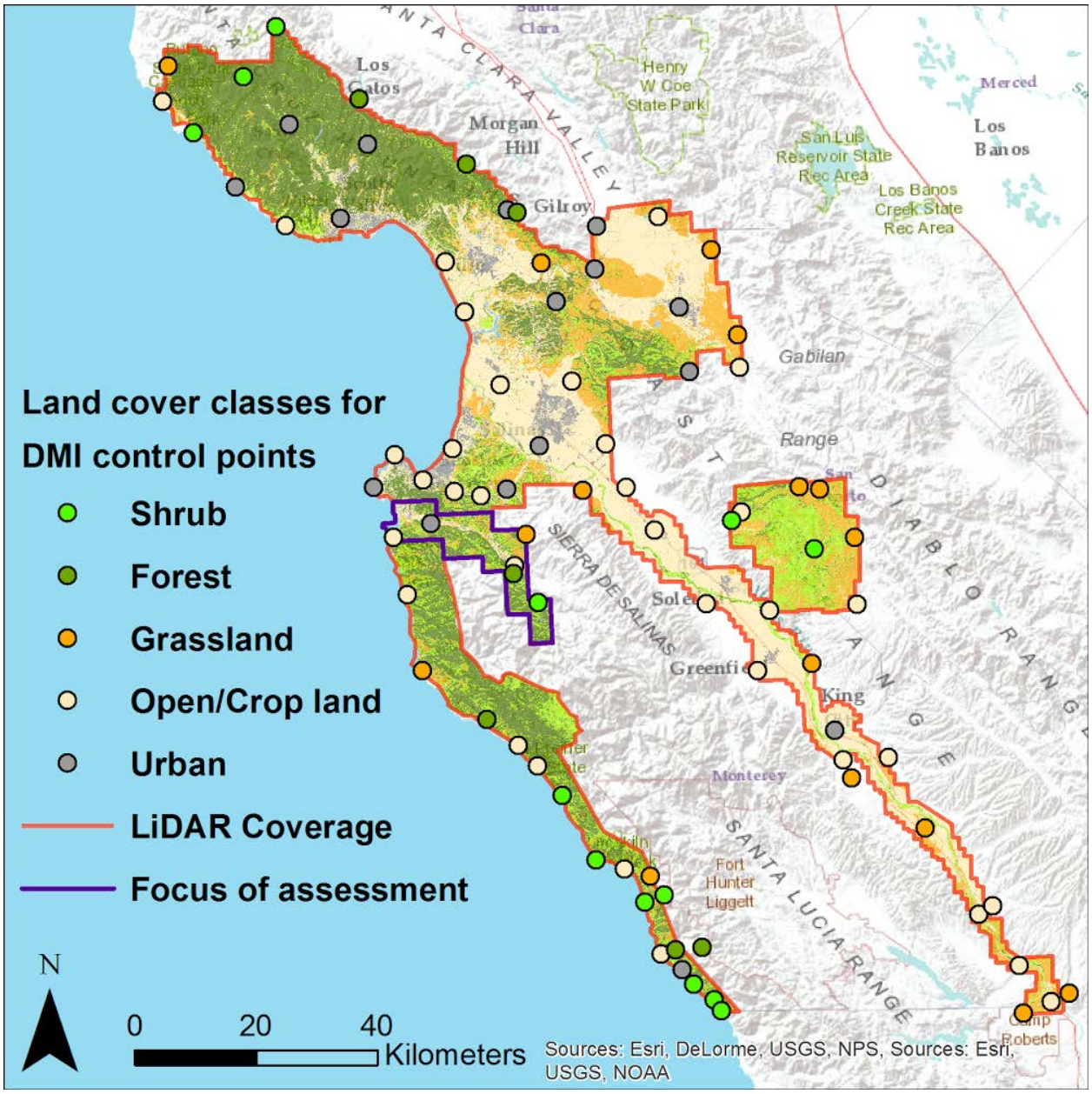
Map 1: Total coverage of Digital Mapping Inc's 2010 LiDAR survey with their control points for accuracy assessment. The area of focus is within the Carmel River Watershed downstream of the San Clemente Dam and includes the reservoir.



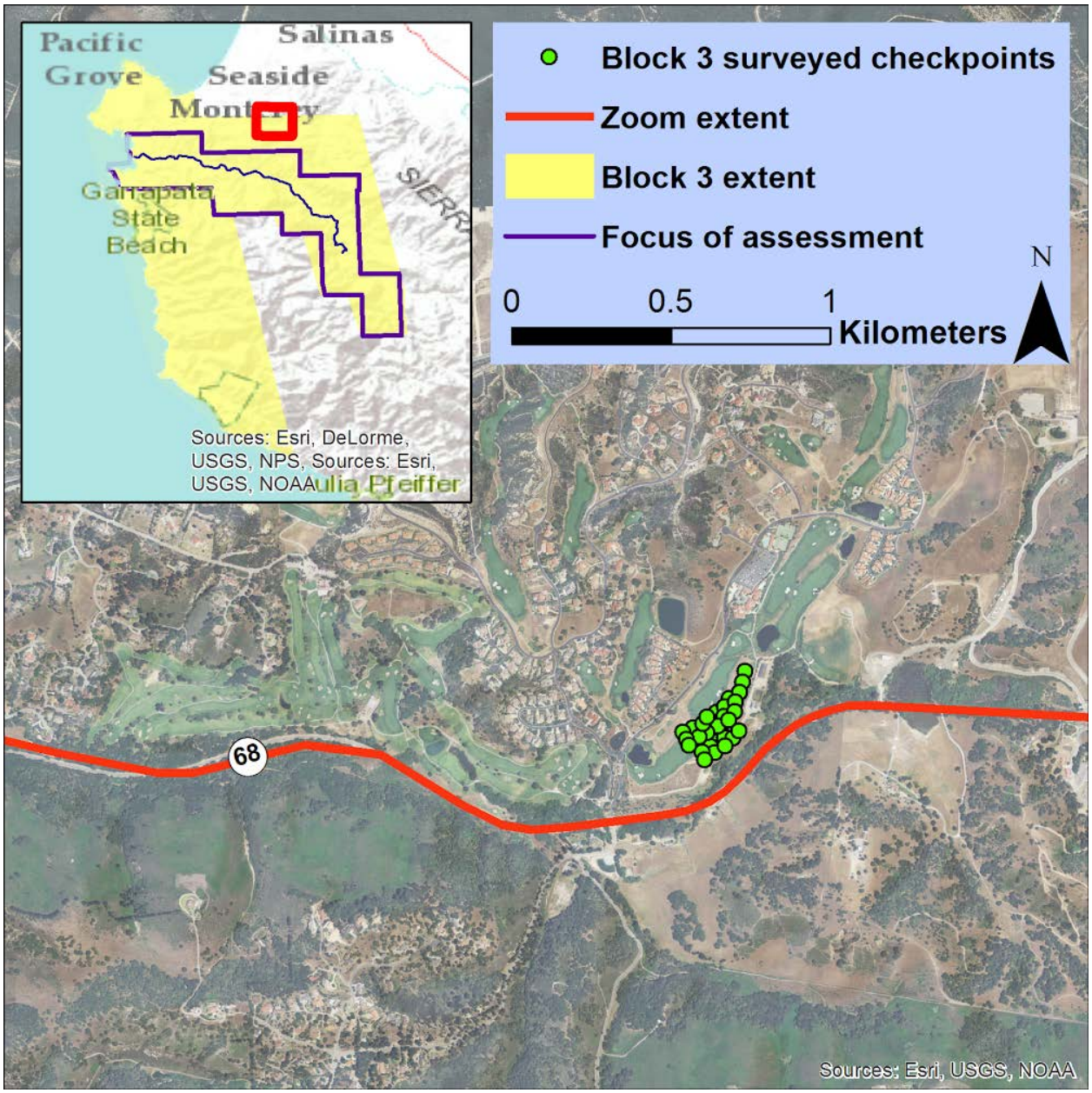
Map 2: The nine blocks surveyed by DMI, which account for differences in terrain and the irregular area. Our area of focus is in block 3.



Map 3: Area of focus within the Carmel River corridor. Points include GPS control points and total station transect points that were analyzed to assess the LiDAR accuracy within the Carmel River corridor.



Map 4: Location of DMI's control points and the respective land cover classification based upon NOAA's C CAP regional land cover classification.



Map 5: DMI's 29 check points, which were used to determine the precision of the bare earth classification.

7 Appendix A – Raw and Analyzed Data

Table 1: Digital Mapping Inc's Control Points. Coordinate System: NAD_1983_StatePlane_California_IV_FIPS_0404_Feet, NAD_1983_StatePlane_California_III_FIPS_0404_Feet,

Points	Zone	NORTHING	EASTING	ELEVATION
AT 13	Zone 4	2199992.807	5858861.66	291.5733
AT 15	Zone 4	2161689.156	5760108.45	20.0089
AT 16	Zone 4	2162250.768	5799076.322	177.7031
AT 18	Zone 4	2164840.313	5862955.255	1075.4418
AT 19	Zone 4	2183385.565	5889863.022	848.1776
AT 20	Zone 4	2165881.413	5890144.06	570.1304
ID 21	Zone 4	2108930.479	5689242.715	21.7069
AT 22	Zone 4	2126122.014	5701315.703	77.1367
AT 23	Zone 4	2111732.149	5716218.468	42.8934
AT 24	Zone 4	2128139.316	5732765.488	118.1036
AT 25	Zone 4	2127848.569	5779976.387	50.8782
AT 26	Zone 4	2127317.988	5815883.078	135.7505
AT 27	Zone 4	2081403.514	5698701.316	129.6852
AT 28	Zone 4	2101967.623	5747063.034	369.8018
AT 29	Zone 4	2102666.442	5802349.11	97.9742
AT 30	Zone 4	2103241.567	5825947.84	183.9864
AT 31	Zone 4	2080178.71	5770598.961	1090.9846
AT 32	Zone 4	2079401.681	5840498.356	122.8953
AT 34 A	Zone 4	2071186.884	5948987.418	1456.9905
AT 34 B	Zone 4	2099853.526	5919842.237	1446.5677
ID 35	Zone 4	2088289.319	5719280.978	92.5054
AT 36	Zone 4	2063366.583	5763937.683	409.4034
AT 38	Zone 4	2065639.047	5926773.085	984.3355
AT 39	Zone 4	2038589.325	5867050.332	171.1383
AT 40	Zone 4	2034757.477	5948623.713	967.9926
AT 41	Zone 4	2033321.294	5900951.51	316.8689
AT 42	Zone 4	2001111.761	5893349.133	334.7734
AT 43	Zone 4	2003566.314	5922755.547	256.3294
AT 44	Zone 4	1966866.924	5933575.949	328.9584
AT 45	Zone 4	1951130.72	5962015.965	446.1401
AT 46	Zone 4	1940762.294	5941618.894	448.7431
AT 47	Zone 4	1911832.469	5980606.913	541.3521
AT 48	Zone 4	1864116.847	6007600.748	535.4057
AT 49	Zone 4	1868189.083	6015378.474	635.2791
AT 50	Zone 4	1835245.395	6028451.972	534.5067
AT 51	Zone 4	1814854.274	6045032.704	611.4281
AT 52	Zone 4	1819213.483	6054805.556	681.5982
AT 54	Zone 4	2059075.341	5762937.496	466.3557
AT 55	Zone 4	2043034.644	5775817.524	821.0355

Points	Zone	NORTHING	EASTING	ELEVATION
AT 57	Zone 4	2008607.05	5711412.541	145.4202
AT 59	Zone 4	1980581.716	5745325.858	763.7292
AT 60	Zone 4	1966004.135	5761665.132	544.0905
AT 61	Zone 4	1954174.339	5771849.259	372.6931
AT 63	Zone 4	1937868.816	5784479.649	359.1325
AT 64	Zone 4	1902081.369	5801446.057	234.5986
AT 65	Zone 4	1896375.985	5816342.664	107.4073
AT 66	Zone 4	1891855.071	5830390.71	1810.3084
AT 67	Zone 4	1877902.994	5826985.928	204.3916
AT 68	Zone 4	1881557.737	5837393.078	3324.4866
AT 69	Zone 4	1849644.156	5834399.16	294.8938
AT 70	Zone 4	1851360.295	5842321.494	2016.3277
AT 71	Zone 4	1840475.739	5845706.149	57.6277
AT 72	Zone 4	1832513.591	5851399.075	487.8411
AT 74	Zone 4	1823487.796	5862275.743	349.4572
AT 75	Zone 4	1817311.386	5866086.901	501.3924
AT 28AA	Zone 4	2105060.15	5761223.661	290.7212
AT 28BB	Zone 4	2104883.858	5732934.046	138.4938
AT 53A	Zone 4	2049986.336	5704955.158	109.5536
AT 73A	Zone 4	1852107.254	5856770.547	3233.878
44BB	Zone 4	1950867.788	5937639.49	383.4146
AT 14A	Zone 4	2205548.21	5792269.433	160.5837
AT 33A	Zone 4	2087385.008	5887974.002	2305.8484
AT 33B	Zone 4	2083032.491	5882640.633	1694.6817
AT 38A	Zone 4	2097972.271	5930895.543	1132.4288
AT 51 B	Zone 4	1809269.628	6029735.648	565.4321
AT 9A	Zone 4	2222424.422	5814132.603	179.7746
AT 70	Zone 4	1851360.295	5842321.494	2016.3277
AT 71	Zone 4	1840475.739	5845706.149	57.6277
AT 72	Zone 4	1832513.591	5851399.075	487.8411
AT 74	Zone 4	1823487.796	5862275.743	349.4572
AT 75	Zone 4	1817311.386	5866086.901	501.3924
AT 28AA	Zone 4	2105060.15	5761223.661	290.7212
AT 28BB	Zone 4	2104883.858	5732934.046	138.4938
AT 53A	Zone 4	2049986.336	5704955.158	109.5536
AT 73A	Zone 4	1852107.254	5856770.547	3233.878
44BB	Zone 4	1950867.788	5937639.49	383.4146
AT 14A	Zone 4	2205548.21	5792269.433	160.5837
AT 33A	Zone 4	2087385.008	5887974.002	2305.8484
AT 33B	Zone 4	2083032.491	5882640.633	1694.6817

Points	Zone	NORTHING	EASTING	ELEVATION
AT 38A	Zone 4	2097972.271	5930895.543	1132.4288
AT 51 B	Zone 4	1809269.628	6029735.648	565.4321
AT 9A	Zone 4	2222424.422	5814132.603	179.7746
AT 70	Zone 4	1851360.295	5842321.494	2016.3277
AT 71	Zone 4	1840475.739	5845706.149	57.6277
AT 72	Zone 4	1832513.591	5851399.075	487.8411
AT 74	Zone 4	1823487.796	5862275.743	349.4572
AT 75	Zone 4	1817311.386	5866086.901	501.3924
AT 28AA	Zone 4	2105060.15	5761223.661	290.7212
AT 28BB	Zone 4	2104883.858	5732934.046	138.4938
AT 53A	Zone 4	2049986.336	5704955.158	109.5536
AT 73A	Zone 4	1852107.254	5856770.547	3233.878
44BB	Zone 4	1950867.788	5937639.49	383.4146
AT 14A	Zone 4	2205548.21	5792269.433	160.5837
AT 33A	Zone 4	2087385.008	5887974.002	2305.8484
AT 33B	Zone 4	2083032.491	5882640.633	1694.6817
AT 38A	Zone 4	2097972.271	5930895.543	1132.4288
AT 51 B	Zone 4	1809269.628	6029735.648	565.4321
AT 9A	Zone 4	2222424.422	5814132.603	179.7746
AT 70	Zone 4	1851360.295	5842321.494	2016.3277
AT 71	Zone 4	1840475.739	5845706.149	57.6277
AT 72	Zone 4	1832513.591	5851399.075	487.8411
AT 1	Zone 3	1886680.579	6020218.135	50.4591
AT 2	Zone 3	1905847.374	6023735.899	132.2452
AT 3	Zone 3	1898850.715	6064455.364	1617.0356
AT 4	Zone 3	1869089.06	6036510.943	98.6204
AT 5	Zone 3	1925589.309	6082801.351	2558.2396
AT 6	Zone 3	1885002.621	6127159.799	1186.1125
AT 7	Zone 3	1848351.721	6184421.02	2704.8345
AT 8	Zone 3	1822774.611	6205805.048	1316.8949
AT 9	Zone 3	1793425.855	6223433.229	72.8551
AT 10	Zone 3	1812810.549	6254059.145	179.4433
AT 11	Zone 3	1817044.618	6287500.138	163.6716
AT 12	Zone 3	1798299.711	6315723.82	442.5504
AT 14	Zone 3	1768017.844	6181052.817	9.4954
AT 3A	Zone 3	1872287.161	6088696.658	493.0011
AT 4A	Zone 3	1839032.31	6058735.278	102.2669
AT 4B	Zone 3	1817551.122	6085168.325	107.7852
AT 6A	Zone 3	1860491.919	6131034.231	1276.3787
AT 6B	Zone 3	1820598.475	6115228.868	34.8553
AT 9BB	Zone 3	1795598.678	6171478.566	176.0628

Points	Zone	NORTHING	EASTING	ELEVATION
AT 6C	Zone 3	1821294.392	6211043.559	929.5027

Table 2: Digital Mapping INC's Survey checkpoints for the Bare Ground Classification. Coordinate System: NAD_1983_StatePlane_California_IV_FIPS_0404_Feet

Point_ID	Easting	Northing	Known_Z	Laser_Z	Dz
28-6n	5747261	2103059	399.582	400.21	0.628
27-6n	5747236	2102948	395.622	396.06	0.438
37-6n	5746703	2102497	384.072	384.47	0.398
20-6n	5746990	2102431	388.972	389.19	0.218
30-6n	5747090	2102783	391.152	391.37	0.218
43-6n	5746957	2102347	391.242	391.43	0.188
32-6n	5746952	2102646	388.922	389.09	0.168
31-6n	5747038	2102696	389.822	389.95	0.128
26-6n	5747200	2102840	394.692	394.8	0.108
19-6n	5747023	2102381	391.282	391.37	0.088
22-6n	5747028	2102597	389.212	389.3	0.088
42-6n	5746874	2102296	391.902	391.99	0.088
21-6n	5746958	2102501	388.642	388.69	0.048
47-6n	5747110	2102373	380.132	380.18	0.048
25-6n	5747150	2102741	392.122	392.16	0.038
35-6n	5746847	2102440	387.082	387.09	0.008
46-6n	5747172	2102445	382.842	382.85	0.008
49-6n	5746919	2102229	375.272	375.28	0.008
41-6n	5746787	2102241	388.292	388.29	-0.002
24-6n	5747137	2102642	392.122	392.12	-0.002
36-6n	5746761	2102400	381.112	381.11	-0.002
38-6n	5746599	2102453	380.122	380.09	-0.032
48-6n	5747023	2102295	377.072	377.04	-0.032
23-6n	5747072	2102559	392.242	392.17	-0.072
39-6n	5746629	2102379	374.442	374.37	-0.072
34-6n	5746806	2102535	398.612	398.53	-0.082
33-6n	5746853	2102602	396.982	396.88	-0.102
40-6n	5746651	2102319	374.412	374.2	-0.212
18-6n	5746810	2102162	372.355	372.1	-0.255

Average dz	0.071
Minimum dz	-0.255
Maximum dz	0.628
Average magnitude	0.13
Root mean square	0.195
Std deviation	0.185

Table 3: GPS Control Points Compared to LiDAR. Coordinate System: NAD83_UTM_Zone10N, Vertical Coordinate System: NAVD88

Point ID	Year	Easting	Northing	GPS Elevation (m)	LiDAR Elevation (m)	Elevation Difference (LiDAR - GPS) (m)
0	NA	615712.427	4033101.855	168.375	168.558	0.183
1	NA	615865.334	4033437.913	162.826	162.828	0.002
2	NA	615819.207	4033397.767	168.891	166.922	-1.969
3	NA	615767.304	4033108.521	140.503	140.718	0.215
4	NA	615762.506	4033132.653	139.572	139.883	0.311
5	NA	615773.115	4033132.118	140.216	140.954	0.738
6	NA	615771.719	4033194.362	137.817	138.356	0.539
7	NA	615779.022	4033185.178	139.229	140.056	0.827
8	NA	615761.371	4033187.822	139.201	141.24	2.039
9	NA	615783.356	4033248.45	138.084	141.322	3.238
10	NA	615803.664	4033249.123	138.554	139	0.446
11	NA	615789.02	4033255.358	137.552	138.369	0.817
12	NA	615768.06	4033205.875	138.699	140.527	1.828
13	NA	615817.546	4033292.78	136.845	137.225	0.380
14	NA	615827.754	4033291.809	137.48	138.658	1.178
15	NA	615812.588	4033303.822	137.785	142.615	4.830
16	NA	615850.537	4033354.768	136.69	137.213	0.523
17	NA	615842.939	4033351.66	137.342	138.251	0.909
18	NA	615870.037	4033357.853	137.287	138.168	0.881
19	NA	615875.781	4033393.798	136.251	139.392	3.141
20	NA	615893.697	4033393.405	136.123	137.078	0.955
21	2013	613094.351	4037489.088	80.223	80.3544	0.131
22	2013	613095.6	4037461.882	80.139	80.3178	0.179
23	2013	612856.873	4037521.988	82.058	82.4575	0.399
24	2013	612865.742	4037526.861	81.967	82.2594	0.292
25	2013	612804.782	4037856.082	77.353	77.5198	0.167
26	2013	612792.638	4037853.564	77.247	77.346	0.099
27	2013	612686.398	4038022.019	75.054	75.31	0.256
28	2013	612686.768	4038082.586	74.875	74.9412	0.066
29	2013	604755.13	4042599.962	28.634	28.8768	0.243
30	2013	604744.502	4042609.435	28.334	28.6634	0.329
31	2013	604698.442	4042700.601	28.21	28.5902	0.380
32	2013	604691.611	4042715.487	28.046	28.0812	0.035
33	2013	601092.67	4044080.004	14.46	14.097	-0.363
34	2013	601070.378	4044096.601	13.321	13.2588	-0.062
35	2013	600920.04	4044251.852	15.84	16.4531	0.613
36	2013	597861.403	4043897.163	4.039	3.97154	-0.067

Point ID	Year	Easting	Northing	GPS Elevation (m)	LiDAR Elevation (m)	Elevation Difference (LiDAR - GPS) (m)
37	2013	597837.699	4043890.76	4.074	4.61772	0.544
38	2013	597607.104	4043834.933	5.778	5.40106	-0.377
39	2013	597604.16	4043840.077	5.254	5.07187	-0.182
40	2013	615314.6763	4032151.338	163.60475	163.798	0.193
41	2013	615342.806	4032185.575	163.85665	164.161	0.304
42	2013	615300.7999	4032190.789	162.90361	163.235	0.331
43	2013	615383.2746	4032143.513	163.71145	164.331	0.620
44	2013	615334.3381	4032121.372	161.97004	162.417	0.447
45	2013	615286.4255	4032235.021	163.23753	163.492	0.254
46	2013	615348.0721	4032211.396	163.77305	163.94	0.167
47	2013	615309.1213	4032198.428	162.216	162.505	0.289
48	2013	615332.4258	4032143.727	163.84104	163.983	0.142
49	2013	615329.7999	4032110.595	163.36829	163.464	0.096
50	2013	615410.2045	4032116.199	164.11069	164.204	0.093
51	2013	615396.2874	4032131.989	163.045	163.315	0.270
52	2013	615449.399	4032134.776	164.867	165.031	0.164
53	2013	615501.433	4032125.116	165.199	165.159	-0.040
54	2013	615435.8727	4032150.831	163.51968	163.802	0.282
55	2013	615445.4835	4032157.227	163.4249	163.732	0.307
56	2013	615454.7237	4032158.355	163.43635	163.553	0.117
57	2013	615457.1122	4032171.566	163.34193	166.726	3.384
58	2013	615487.0434	4032147.802	163.42598	164.147	0.721
59	2013	615492.8254	4032165.865	163.89879	168.748	4.849

Average Difference (m)	0.628
Minimum Difference (m)	-1.969
Maximum Difference (m)	4.849
Root Mean Square Error (m)	1.294
Standard Deviation (m)	1.141

Table 4: Total Station Transect Points Compared to LiDAR. Coordinate System: NAD83_UTM_Zone10N, Vertical Coordinate System: NAVD88

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
0	2013	613095.6	4037462	80.21	no	80.32	0.10
1	2013	613089.2	4037514	77.76	no	79.33	1.56
2	2013	613085.8	4037507	79.20	yes	79.82	0.62
3	2013	613086	4037508	78.04	yes	79.82	1.78
4	2013	613086.1	4037509	77.63	yes	79.69	2.07
5	2013	613086.2	4037510	77.33	yes	79.69	2.37
6	2013	613086.2	4037511	77.38	yes	79.69	2.32
7	2013	613086.3	4037512	77.50	yes	79.48	1.98
8	2013	613086.4	4037513	77.55	yes	79.48	1.93
9	2013	613086.4	4037514	77.60	yes	79.48	1.88
10	2013	613086.6	4037515	77.59	yes	79.21	1.62
11	2013	613086.6	4037516	77.56	yes	79.21	1.64
12	2013	613086.7	4037517	77.52	yes	79.21	1.68
13	2013	613086.7	4037518	77.50	yes	78.92	1.43
14	2013	613086.8	4037519	77.50	yes	78.92	1.43
15	2013	613086.9	4037520	77.47	yes	78.92	1.46
16	2013	613086.9	4037521	77.55	yes	78.64	1.10
17	2013	613087	4037522	77.69	yes	78.64	0.95
18	2013	613087.2	4037523	77.82	yes	78.64	0.82
19	2013	613087.4	4037525	77.71	yes	78.36	0.65
20	2013	613087.2	4037526	77.57	yes	78.36	0.79
21	2013	613087.3	4037527	77.45	yes	78.08	0.64
22	2013	613087.4	4037529	77.34	yes	78.08	0.74
23	2013	613087.6	4037530	77.50	yes	77.99	0.49
24	2013	613087.5	4037531	77.77	yes	77.99	0.22
25	2013	613087.5	4037532	77.94	yes	77.99	0.05
26	2013	613087.6	4037533	77.90	yes	78.18	0.28
27	2013	613087.7	4037534	77.88	yes	78.18	0.30
28	2013	613087.7	4037535	77.83	yes	78.18	0.35
29	2013	613087.8	4037537	77.95	yes	78.35	0.40
30	2013	613087.8	4037538	77.89	yes	78.35	0.47
31	2013	613087.9	4037540	77.97	no	78.55	0.58
32	2013	613088	4037542	78.02	no	78.63	0.61
33	2013	613087.9	4037543	78.02	no	78.85	0.83

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
34	2013	613087.9	4037548	78.86	yes	79.49	0.63
35	2013	613087.8	4037550	80.03	yes	79.49	-0.54
36	2013	613087.8	4037551	80.13	yes	79.49	-0.63
37	2013	613087.9	4037551	80.19	yes	79.49	-0.69
38	2013	613085.8	4037507	79.20	no	79.82	0.62
39	2013	613031.3	4037528	78.01	yes	78.19	0.19
40	2013	613031.3	4037528	78.01	yes	78.19	0.19
41	2013	613032.8	4037513	79.04	yes	79.66	0.62
42	2013	613032.8	4037513	78.86	yes	79.66	0.81
43	2013	613032.9	4037514	78.78	yes	79.66	0.88
44	2013	613032.9	4037515	78.49	yes	79.39	0.90
45	2013	613033	4037516	78.29	yes	79.39	1.10
46	2013	613033	4037517	78.03	yes	79.39	1.36
47	2013	613033	4037518	77.64	no	79.09	1.45
48	2013	613033.1	4037519	77.32	no	78.97	1.65
49	2013	613033	4037520	77.13	no	79.09	1.97
50	2013	613033.1	4037521	77.17	yes	78.56	1.39
51	2013	613033.2	4037522	77.16	yes	78.56	1.40
52	2013	613033.3	4037523	77.18	yes	78.56	1.38
53	2013	613033.5	4037524	77.18	yes	78.15	0.97
54	2013	613033.5	4037525	77.23	yes	78.15	0.92
55	2013	613033.6	4037526	77.36	yes	78.15	0.79
56	2013	613033.6	4037526	77.58	yes	78.15	0.57
57	2013	613033.7	4037527	77.95	yes	77.93	-0.03
58	2013	613033.6	4037528	77.90	yes	77.93	0.02
59	2013	613033.7	4037529	77.69	yes	77.93	0.23
60	2013	613033.8	4037530	77.66	yes	78.17	0.51
61	2013	613033.8	4037531	77.66	yes	78.17	0.51
62	2013	613033.9	4037532	77.88	yes	78.17	0.29
63	2013	613034.1	4037533	77.97	yes	78.01	0.04
64	2013	613034.2	4037534	77.84	yes	78.01	0.17
65	2013	613034.4	4037535	77.64	yes	78.01	0.37
66	2013	613034.5	4037536	77.72	yes	77.86	0.15
67	2013	613034.5	4037537	77.61	yes	77.86	0.25
68	2013	613034.7	4037538	77.76	yes	77.86	0.10

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
69	2013	613034.8	4037539	77.70	yes	77.79	0.09
70	2013	613034.9	4037540	77.64	yes	77.79	0.15
71	2013	613035	4037541	77.60	yes	77.79	0.19
72	2013	613035.1	4037542	77.64	yes	78.32	0.68
73	2013	613035.1	4037542	77.76	yes	78.32	0.56
74	2013	613032.8	4037513	79.04	no	79.66	0.62
75	2013	612987.8	4037522	77.31	no	79.88	2.57
76	2013	612967.5	4037522	77.03	no	80.25	3.22
77	2013	612970.4	4037517	78.19	yes	81.62	3.44
78	2013	612970.5	4037517	78.09	yes	81.62	3.54
79	2013	612970.4	4037518	77.79	yes	81.15	3.36
80	2013	612970.4	4037519	77.48	yes	81.15	3.67
81	2013	612970.7	4037520	77.06	yes	81.15	4.09
82	2013	612970.7	4037521	77.06	yes	80.84	3.78
83	2013	612970.7	4037522	77.01	yes	80.84	3.84
84	2013	612970.9	4037522	76.72	yes	80.84	4.12
85	2013	612970.9	4037523	76.64	yes	80.84	4.20
86	2013	612970.9	4037524	76.68	yes	79.93	3.26
87	2013	612970.9	4037524	76.65	yes	79.93	3.28
88	2013	612971	4037525	76.75	yes	79.93	3.19
89	2013	612971.1	4037526	76.97	yes	79.93	2.96
90	2013	612971.1	4037527	77.11	yes	78.98	1.87
91	2013	612971.1	4037528	77.39	yes	78.98	1.59
92	2013	612971.2	4037529	77.57	yes	78.98	1.41
93	2013	612971.4	4037530	77.80	yes	78.32	0.52
94	2013	612971.5	4037531	77.84	yes	78.32	0.48
95	2013	612971.7	4037533	77.80	yes	77.79	-0.02
96	2013	612971.7	4037534	77.64	yes	77.79	0.15
97	2013	612971.9	4037535	77.48	yes	77.79	0.31
98	2013	612972	4037536	77.46	no	77.19	-0.27
99	2013	612972.1	4037537	77.45	yes	77.52	0.07
100	2013	612972.3	4037538	77.44	yes	77.52	0.08
101	2013	612972.5	4037539	77.62	yes	77.24	-0.39
102	2013	612972.6	4037540	77.85	yes	77.24	-0.61
103	2013	612972.7	4037541	77.79	yes	77.24	-0.55

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
104	2013	612972.6	4037541	77.95	yes	77.24	-0.71
105	2013	612970.4	4037517	78.18	no	81.62	3.44
106	2013	612913.8	4037534	77.17	no	76.99	-0.18
107	2013	612901.2	4037525	78.33	yes	78.85	0.52
108	2013	612901.3	4037525	78.18	yes	78.85	0.67
109	2013	612901.6	4037526	77.81	yes	78.85	1.04
110	2013	612902	4037527	77.56	no	78.00	0.44
111	2013	612902.3	4037528	77.39	yes	77.78	0.39
112	2013	612902.7	4037529	77.13	yes	77.78	0.66
113	2013	612903.1	4037530	76.96	yes	76.93	-0.03
114	2013	612903.4	4037530	76.60	yes	76.93	0.33
115	2013	612903.5	4037531	77.45	yes	76.93	-0.52
116	2013	612903.8	4037531	76.47	yes	76.93	0.46
117	2013	612903.9	4037532	76.24	yes	76.93	0.69
118	2013	612904.4	4037533	76.21	yes	77.07	0.86
119	2013	612904.8	4037534	76.03	yes	77.07	1.04
120	2013	612905.1	4037534	76.01	yes	77.13	1.11
121	2013	612905.6	4037535	76.04	yes	77.13	1.08
122	2013	612906	4037536	76.28	yes	77.34	1.06
123	2013	612906.3	4037537	76.61	yes	77.34	0.73
124	2013	612906.6	4037538	76.84	yes	77.34	0.50
125	2013	612906.8	4037538	76.92	yes	77.34	0.42
126	2013	612907.1	4037539	77.01	yes	77.55	0.54
127	2013	612907.5	4037540	77.26	yes	77.55	0.29
128	2013	612908	4037541	77.41	yes	77.55	0.14
129	2013	612908.6	4037542	77.40	yes	77.83	0.44
130	2013	612908.9	4037543	77.44	yes	77.83	0.39
131	2013	612909.4	4037543	77.38	yes	77.83	0.45
132	2013	612909.7	4037544	77.25	yes	77.83	0.58
133	2013	612910.3	4037546	77.28	yes	78.05	0.77
134	2013	612910.8	4037547	77.36	yes	78.05	0.69
135	2013	612911.5	4037548	77.43	yes	78.16	0.73
136	2013	612911.9	4037549	77.44	yes	78.16	0.71
137	2013	612912.8	4037551	77.46	yes	78.16	0.70
138	2013	612913.4	4037552	77.52	no	78.37	0.85

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
139	2013	612914.7	4037554	77.57	yes	78.28	0.70
140	2013	612915.6	4037556	77.46	yes	78.28	0.82
141	2013	612915.7	4037556	77.52	yes	78.28	0.76
142	2013	612901.2	4037525	78.33	no	78.85	0.52
143	2013	612851.6	4037541	77.05	no	78.52	1.47
144	2013	612846.5	4037538	78.13	yes	80.78	2.65
145	2013	612846.5	4037538	78.05	yes	80.78	2.72
146	2013	612846.7	4037539	77.83	yes	80.78	2.94
147	2013	612846.8	4037539	77.73	yes	79.78	2.05
148	2013	612847	4037540	77.28	yes	79.78	2.49
149	2013	612847.1	4037540	77.19	yes	79.78	2.59
150	2013	612847.2	4037541	77.16	yes	79.17	2.02
151	2013	612847.3	4037541	76.91	yes	79.17	2.26
152	2013	612847.5	4037542	76.79	yes	78.18	1.39
153	2013	612847.7	4037543	76.63	yes	78.18	1.55
154	2013	612848	4037544	76.53	yes	78.18	1.65
155	2013	612848.1	4037546	76.41	yes	77.14	0.72
156	2013	612848.3	4037546	76.41	yes	77.14	0.73
157	2013	612848.5	4037547	76.45	yes	77.14	0.69
158	2013	612848.7	4037548	76.45	yes	76.91	0.46
159	2013	612848.8	4037549	76.50	yes	76.91	0.41
160	2013	612849.1	4037550	76.52	yes	76.91	0.39
161	2013	612849.3	4037551	76.49	yes	76.85	0.36
162	2013	612849.6	4037552	76.52	yes	76.85	0.34
163	2013	612849.7	4037553	76.57	yes	76.85	0.28
164	2013	612850	4037554	76.76	yes	77.08	0.32
165	2013	612850.1	4037554	76.92	yes	77.08	0.16
166	2013	612850.2	4037556	77.19	yes	77.15	-0.03
167	2013	612850.5	4037557	77.18	yes	77.15	-0.03
168	2013	612850.6	4037558	77.15	yes	77.31	0.15
169	2013	612850.7	4037558	77.31	yes	77.31	-0.01
170	2013	612846.5	4037538	78.13	no	80.78	2.65
171	2013	612795.1	4037579	76.85	no	77.83	0.99
172	2013	612792.2	4037568	77.65	yes	80.57	2.92
173	2013	612792	4037568	77.09	yes	80.57	3.48

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
174	2013	612792.3	4037569	76.66	no	80.33	3.66
175	2013	612792.5	4037569	76.49	yes	79.17	2.68
176	2013	612792.9	4037570	76.36	yes	79.17	2.82
177	2013	612793.5	4037571	76.38	yes	79.17	2.79
178	2013	612793.9	4037572	76.44	yes	79.17	2.74
179	2013	612794.5	4037573	76.49	yes	78.71	2.22
180	2013	612794.9	4037574	76.66	yes	78.71	2.05
181	2013	612795.3	4037575	76.62	no	77.88	1.26
182	2013	612795.9	4037575	76.57	yes	77.46	0.89
183	2013	612796.2	4037576	76.51	yes	77.46	0.94
184	2013	612796.8	4037577	76.51	yes	77.46	0.95
185	2013	612797.1	4037578	76.57	yes	77.46	0.89
186	2013	612797.7	4037579	76.63	yes	77.26	0.62
187	2013	612798.1	4037580	76.68	yes	77.26	0.58
188	2013	612798.4	4037580	76.72	yes	77.50	0.79
189	2013	612798.6	4037581	76.96	yes	77.50	0.54
190	2013	612799.1	4037582	77.01	yes	77.90	0.90
191	2013	612799.5	4037583	77.14	yes	77.90	0.77
192	2013	612800	4037583	77.14	yes	77.90	0.77
193	2013	612800.5	4037584	77.20	yes	77.92	0.72
194	2013	612801.1	4037585	77.33	yes	77.92	0.59
195	2013	612801.1	4037585	77.44	yes	77.92	0.48
196	2013	612792.2	4037568	77.65	no	80.57	2.92
197	2013	612857.1	4037522	81.97	no	82.46	0.49
198	2013	612846.6	4037538	77.98	no	80.78	2.80
199	2013	612865.6	4037527	82.00	no	82.26	0.26
200	2013	612767.8	4037845	75.44	yes	76.45	1.01
201	2013	612767.8	4037845	75.34	yes	76.45	1.11
202	2013	612769.2	4037845	75.34	yes	75.81	0.47
203	2013	612770.2	4037845	75.28	yes	75.81	0.53
204	2013	612770.7	4037845	75.24	yes	75.81	0.57
205	2013	612771.7	4037846	75.10	yes	75.39	0.29
206	2013	612772.6	4037846	74.91	yes	75.39	0.48
207	2013	612773.6	4037846	74.76	yes	75.39	0.63
208	2013	612774.6	4037846	74.60	no	75.18	0.58

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
209	2013	612775.6	4037847	74.38	yes	75.19	0.81
210	2013	612776.5	4037847	74.25	yes	75.19	0.94
211	2013	612777.5	4037847	74.09	yes	75.30	1.21
212	2013	612778.4	4037847	73.97	yes	75.30	1.34
213	2013	612779.4	4037848	73.87	yes	75.30	1.44
214	2013	612780.3	4037848	73.80	yes	75.32	1.52
215	2013	612781.5	4037848	73.94	yes	75.32	1.38
216	2013	612782.3	4037849	74.08	yes	75.32	1.25
217	2013	612783.3	4037849	74.33	yes	75.31	0.98
218	2013	612784.3	4037849	74.76	yes	75.31	0.55
219	2013	612785.2	4037850	75.05	no	75.24	0.19
220	2013	612786.2	4037850	75.39	yes	76.10	0.71
221	2013	612786.5	4037850	75.59	yes	76.10	0.51
222	2013	612787.1	4037850	75.77	yes	76.10	0.33
223	2013	612788.2	4037850	76.04	yes	76.10	0.06
224	2013	612788.1	4037850	76.15	yes	76.10	-0.06
225	2013	612758.8	4037915	74.39	no	75.23	0.84
226	2013	612782.9	4037856	74.73	no	75.29	0.56
227	2013	612750.1	4037905	75.98	yes	75.81	-0.17
228	2013	612750.2	4037905	75.82	yes	75.81	-0.02
229	2013	612751	4037905	75.78	yes	75.81	0.03
230	2013	612751.9	4037906	75.53	yes	75.81	0.27
231	2013	612752.8	4037906	75.27	yes	75.35	0.07
232	2013	612753.7	4037907	75.01	yes	75.35	0.34
233	2013	612754.6	4037907	74.92	yes	75.35	0.43
234	2013	612755.5	4037907	74.91	yes	75.35	0.44
235	2013	612756.3	4037908	74.82	yes	75.23	0.41
236	2013	612757.2	4037908	74.76	yes	75.23	0.47
237	2013	612758.1	4037909	74.68	yes	75.23	0.55
238	2013	612759	4037909	74.56	yes	75.18	0.62
239	2013	612759.9	4037910	74.44	yes	75.18	0.74
240	2013	612760.6	4037910	74.29	yes	75.18	0.90
241	2013	612761.5	4037911	74.18	no	75.27	1.09
242	2013	612762.4	4037911	74.12	yes	75.32	1.20
243	2013	612763.3	4037912	74.05	yes	75.32	1.27

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
244	2013	612764.2	4037912	74.01	yes	75.32	1.30
245	2013	612765.1	4037913	74.06	yes	75.37	1.31
246	2013	612765.9	4037913	74.17	yes	75.37	1.20
247	2013	612766.8	4037914	74.43	yes	75.29	0.87
248	2013	612767.9	4037914	74.78	yes	75.29	0.52
249	2013	612768.8	4037914	74.95	yes	76.26	1.32
250	2013	612769.2	4037914	75.02	yes	76.26	1.24
251	2013	612769.2	4037914	75.14	yes	76.26	1.12
252	2013	612750.1	4037905	75.97	no	75.81	-0.17
253	2013	612745.1	4037963	74.89	no	75.19	0.30
254	2013	612758.8	4037915	74.40	no	75.23	0.83
255	2013	612722.5	4037963	75.92	yes	75.72	-0.21
256	2013	612722.5	4037963	75.72	yes	75.72	0.00
257	2013	612723.5	4037963	75.62	yes	75.72	0.10
258	2013	612724.5	4037963	75.54	yes	75.72	0.18
259	2013	612726.5	4037963	75.51	yes	75.74	0.23
260	2013	612727.5	4037964	75.49	yes	75.74	0.25
261	2013	612728.5	4037964	75.45	yes	75.69	0.23
262	2013	612729.4	4037964	75.42	yes	75.69	0.27
263	2013	612732.4	4037964	75.34	no	75.58	0.25
264	2013	612734.4	4037964	75.29	yes	75.48	0.19
265	2013	612735.4	4037965	75.24	yes	75.48	0.25
266	2013	612736.3	4037965	75.16	yes	75.48	0.33
267	2013	612737.3	4037965	75.06	yes	75.48	0.42
268	2013	612738.3	4037965	74.99	no	75.38	0.39
269	2013	612739.3	4037965	75.07	yes	75.30	0.23
270	2013	612740.2	4037966	75.02	yes	75.30	0.28
271	2013	612742.3	4037966	74.92	yes	75.28	0.36
272	2013	612743.2	4037966	74.86	yes	75.28	0.42
273	2013	612744.3	4037966	74.91	yes	75.11	0.20
274	2013	612745.3	4037966	74.94	yes	75.11	0.17
275	2013	612746.3	4037967	74.97	yes	75.11	0.15
276	2013	612747.2	4037967	74.99	yes	75.28	0.29
277	2013	612748.2	4037967	75.05	yes	75.28	0.23
278	2013	612749.2	4037967	75.08	yes	75.28	0.20

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
279	2013	612750.2	4037967	75.08	yes	75.36	0.28
280	2013	612751.2	4037967	75.11	yes	75.36	0.25
281	2013	612752.2	4037968	75.36	yes	75.36	0.00
282	2013	612753.2	4037968	75.55	yes	75.64	0.08
283	2013	612754.2	4037968	75.53	yes	75.64	0.10
284	2013	612755.1	4037968	75.60	yes	75.64	0.04
285	2013	612756.2	4037968	75.49	no	75.82	0.33
286	2013	612758.1	4037969	75.47	no	75.72	0.25
287	2013	612760.1	4037969	75.38	yes	75.59	0.21
288	2013	612761.1	4037969	75.44	yes	75.59	0.15
289	2013	612762.1	4037969	75.62	yes	75.88	0.26
290	2013	612763	4037969	75.76	yes	75.88	0.12
291	2013	612764	4037970	75.81	yes	75.88	0.07
292	2013	612765.5	4037970	75.99	yes	76.61	0.62
293	2013	612765.5	4037970	76.11	yes	76.61	0.50
294	2013	612722.5	4037963	75.92	no	75.72	-0.20
295	2013	612732.8	4038004	74.19	no	74.30	0.10
296	2013	612745.1	4037963	74.90	no	75.19	0.28
297	2013	612719.6	4038015	75.61	no	75.52	-0.09
298	2013	612723.3	4038019	74.85	yes	74.97	0.12
299	2013	612723.3	4038019	74.67	yes	74.97	0.30
300	2013	612724.3	4038019	74.64	yes	74.97	0.33
301	2013	612725.3	4038019	74.65	yes	75.06	0.42
302	2013	612726.3	4038019	74.56	yes	75.06	0.50
303	2013	612727.2	4038019	74.41	yes	75.06	0.66
304	2013	612728.3	4038019	74.06	yes	73.93	-0.14
305	2013	612729.3	4038019	73.88	yes	73.93	0.05
306	2013	612730	4038019	73.70	yes	73.93	0.23
307	2013	612730.7	4038019	73.78	yes	73.93	0.14
308	2013	612731.2	4038019	73.55	yes	73.93	0.38
309	2013	612731.8	4038019	73.49	yes	74.62	1.14
310	2013	612732.1	4038019	73.64	yes	74.62	0.99
311	2013	612732.3	4038019	73.94	yes	74.62	0.68
312	2013	612733	4038019	73.72	yes	74.62	0.91
313	2013	612733.8	4038019	73.69	yes	74.62	0.93

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
314	2013	612734.8	4038019	73.86	yes	74.99	1.13
315	2013	612736.3	4038019	74.26	yes	74.99	0.73
316	2013	612737.1	4038019	74.38	yes	74.99	0.61
317	2013	612737.5	4038019	74.51	yes	74.81	0.30
318	2013	612738.8	4038019	74.58	yes	74.81	0.23
319	2013	612739.3	4038019	74.58	yes	74.81	0.23
320	2013	612739.8	4038019	74.61	yes	74.81	0.20
321	2013	612739.9	4038019	74.69	yes	74.81	0.11
322	2013	612723.3	4038019	74.85	no	74.97	0.12
323	2013	612690.8	4038020	75.47	no	75.52	0.05
324	2013	612686.5	4038022	75.09	no	75.32	0.23
325	2013	612686.7	4038083	74.92	no	75.03	0.11
326	2013	604698.5	4042701	28.16	no	28.86	0.69
327	2013	604663.5	4042715	25.75	yes	26.00	0.25
328	2013	604663.5	4042715	25.60	yes	26.00	0.40
329	2013	604664.5	4042715	25.62	yes	26.00	0.37
330	2013	604665.5	4042715	25.59	yes	26.00	0.41
331	2013	604666.5	4042715	25.58	yes	26.12	0.54
332	2013	604667.5	4042715	25.53	yes	26.12	0.59
333	2013	604668.5	4042715	25.58	yes	26.12	0.55
334	2013	604669.5	4042715	25.56	yes	26.01	0.44
335	2013	604670.5	4042715	25.54	yes	26.01	0.47
336	2013	604672.5	4042715	25.41	yes	25.73	0.31
337	2013	604672.9	4042715	25.28	yes	25.73	0.45
338	2013	604674.5	4042715	24.85	yes	25.73	0.88
339	2013	604675.5	4042715	24.81	yes	25.47	0.66
340	2013	604676.5	4042715	24.71	yes	25.47	0.76
341	2013	604677.5	4042715	24.79	yes	25.47	0.68
342	2013	604678.5	4042715	24.85	yes	25.49	0.64
343	2013	604679.5	4042715	24.97	yes	25.49	0.51
344	2013	604680.5	4042715	25.06	yes	25.49	0.42
345	2013	604681.5	4042715	25.09	yes	26.36	1.26
346	2013	604682.4	4042715	24.98	yes	26.36	1.37
347	2013	604682.8	4042715	25.04	yes	26.36	1.32
348	2013	604683.6	4042715	25.37	yes	26.36	0.99

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
349	2013	604684.5	4042715	25.76	yes	26.36	0.59
350	2013	604685.4	4042715	26.10	yes	27.17	1.07
351	2013	604685.7	4042715	26.20	yes	27.17	0.96
352	2013	604686.4	4042715	26.36	yes	27.17	0.80
353	2013	604687.4	4042715	26.61	yes	27.17	0.56
354	2013	604688.5	4042715	26.85	yes	28.08	1.23
355	2013	604689.4	4042715	27.16	yes	28.08	0.92
356	2013	604690.4	4042715	27.56	yes	28.08	0.53
357	2013	604691.9	4042715	27.98	yes	28.65	0.68
358	2013	604692.9	4042715	28.04	yes	28.65	0.61
359	2013	604693.8	4042715	28.16	yes	28.79	0.63
360	2013	604693.9	4042715	28.30	yes	28.79	0.50
361	2013	604663.5	4042715	25.74	no	26.00	0.25
362	2013	604702.7	4042692	28.42	no	28.77	0.35
363	2013	604681.5	4042663	24.90	no	25.94	1.04
364	2013	604671.1	4042681	27.31	no	26.87	-0.44
365	2013	604672.4	4042680	26.01	no	26.90	0.89
366	2013	604675.4	4042678	25.92	no	26.51	0.59
367	2013	604676.1	4042677	25.89	yes	26.41	0.52
368	2013	604677.5	4042676	25.76	yes	26.41	0.65
369	2013	604678.6	4042675	25.41	yes	25.97	0.56
370	2013	604679.5	4042675	25.49	yes	25.97	0.48
371	2013	604680.2	4042674	25.51	yes	25.84	0.33
372	2013	604681	4042674	25.48	yes	25.84	0.36
373	2013	604681.9	4042673	25.43	yes	25.81	0.38
374	2013	604682.7	4042672	25.38	yes	25.81	0.43
375	2013	604683.5	4042672	25.33	yes	25.81	0.48
376	2013	604684.3	4042671	25.22	no	25.76	0.54
377	2013	604685.2	4042671	25.09	yes	25.62	0.53
378	2013	604686	4042670	24.94	yes	25.62	0.68
379	2013	604686.5	4042670	24.90	yes	25.62	0.72
380	2013	604687.3	4042669	24.94	yes	25.62	0.67
381	2013	604688.2	4042669	25.07	yes	25.79	0.72
382	2013	604688.8	4042668	25.54	yes	25.79	0.25
383	2013	604689.8	4042668	25.45	no	25.89	0.45

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
384	2013	604690.8	4042667	25.53	yes	26.18	0.66
385	2013	604692.8	4042666	25.73	yes	26.18	0.45
386	2013	604694.6	4042665	26.00	yes	26.65	0.64
387	2013	604695.4	4042665	26.19	yes	26.65	0.46
388	2013	604697.1	4042664	26.39	yes	27.05	0.66
389	2013	604698.8	4042662	26.59	yes	27.05	0.46
390	2013	604700.5	4042661	26.72	yes	27.14	0.43
391	2013	604701.1	4042661	26.70	yes	27.14	0.44
392	2013	604701.1	4042661	26.82	yes	27.14	0.32
393	2013	604701.1	4042661	26.82	yes	27.14	0.32
394	2013	604671.1	4042681	27.31	yes	26.87	-0.44
395	2013	604671.1	4042681	27.32	yes	26.87	-0.44
396	2013	604699.3	4042634	24.46	no	27.16	2.70
397	2013	604736.8	4042632	25.19	no	26.16	0.97
398	2013	604699.3	4042634	24.47	no	27.16	2.70
399	2013	604743.3	4042619	26.58	yes	26.80	0.22
400	2013	604743.3	4042619	26.43	yes	26.80	0.37
401	2013	604743.2	4042620	26.33	yes	26.60	0.27
402	2013	604743.1	4042621	26.19	yes	26.60	0.41
403	2013	604742.8	4042622	26.02	yes	26.60	0.58
404	2013	604742.6	4042623	25.92	no	26.40	0.48
405	2013	604742.3	4042624	25.86	yes	26.47	0.61
406	2013	604742.1	4042625	25.86	yes	26.47	0.61
407	2013	604741.9	4042626	25.91	yes	26.42	0.51
408	2013	604741.8	4042627	25.95	yes	26.42	0.47
409	2013	604741.5	4042628	25.94	yes	26.42	0.48
410	2013	604741.3	4042629	25.92	yes	25.83	-0.09
411	2013	604741.1	4042630	25.73	yes	25.83	0.11
412	2013	604740.8	4042631	25.24	yes	25.83	0.60
413	2013	604740.7	4042632	25.17	yes	26.19	1.01
414	2013	604740.4	4042633	25.10	yes	26.19	1.09
415	2013	604740.3	4042634	25.05	yes	26.19	1.13
416	2013	604739.9	4042635	25.09	yes	26.19	1.09
417	2013	604739.7	4042636	25.04	yes	26.69	1.65
418	2013	604739.5	4042637	25.07	yes	26.69	1.62

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
419	2013	604739.3	4042638	25.14	no	26.67	1.53
420	2013	604739.1	4042639	25.43	yes	27.18	1.75
421	2013	604739	4042639	25.67	yes	27.18	1.51
422	2013	604739	4042640	26.06	yes	27.18	1.12
423	2013	604743.3	4042619	26.58	no	26.80	0.22
424	2013	604758.7	4042624	25.74	no	26.38	0.64
425	2013	604793.3	4042628	25.05	no	26.16	1.11
426	2013	604796.7	4042624	25.98	yes	26.73	0.75
427	2013	604796.7	4042624	25.89	yes	26.73	0.83
428	2013	604796.6	4042625	25.80	yes	26.73	0.92
429	2013	604796.8	4042626	25.64	yes	26.35	0.71
430	2013	604796.7	4042626	25.54	yes	26.35	0.81
431	2013	604796.8	4042627	25.11	yes	26.35	1.23
432	2013	604796.8	4042628	24.87	yes	26.35	1.48
433	2013	604796.8	4042629	24.66	yes	26.08	1.43
434	2013	604796.7	4042630	24.57	yes	26.08	1.52
435	2013	604796.8	4042631	24.55	yes	26.08	1.54
436	2013	604796.8	4042632	24.63	yes	26.01	1.37
437	2013	604796.8	4042632	24.69	yes	26.01	1.32
438	2013	604796.7	4042633	24.84	yes	26.01	1.17
439	2013	604796.8	4042634	25.16	yes	26.01	0.85
440	2013	604796.9	4042635	25.54	yes	26.18	0.64
441	2013	604796.9	4042636	25.84	yes	26.18	0.34
442	2013	604797	4042637	26.08	yes	26.18	0.11
443	2013	604796.8	4042638	26.06	yes	26.18	0.12
444	2013	604796.7	4042639	26.25	yes	26.53	0.27
445	2013	604796.7	4042639	26.41	yes	26.53	0.12
446	2013	604796.7	4042624	25.98	no	26.73	0.75
447	2013	604751.9	4042621	27.98	no	26.70	-1.29
448	2013	604744.5	4042609	28.21	no	28.66	0.46
449	2013	604755.1	4042600	28.51	no	28.88	0.37
450	2014	601113.4	4044084	14.25	yes	14.31	0.06
451	2014	601113.4	4044084	14.12	yes	14.31	0.19
452	2014	601113.2	4044083	14.03	yes	14.31	0.28
453	2014	601113	4044082	13.96	yes	14.03	0.07

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
454	2014	601112.8	4044081	14.03	yes	14.03	0.00
455	2014	601112.6	4044080	14.02	yes	14.06	0.04
456	2014	601112.5	4044079	13.98	yes	14.06	0.08
457	2014	601112.3	4044078	14.02	yes	14.02	0.01
458	2014	601112.1	4044077	14.07	yes	14.02	-0.05
459	2014	601111.9	4044076	14.14	yes	14.11	-0.03
460	2014	601111.8	4044075	14.18	yes	14.11	-0.07
461	2014	601111.6	4044074	14.24	yes	14.11	-0.13
462	2014	601111.5	4044073	14.22	yes	14.18	-0.04
463	2014	601111.3	4044072	14.19	yes	14.18	-0.01
464	2014	601111.1	4044072	14.20	yes	14.18	-0.02
465	2014	601111	4044071	14.20	yes	14.18	-0.02
466	2014	601110.8	4044070	14.13	yes	13.96	-0.17
467	2014	601110.7	4044069	14.07	yes	13.96	-0.11
468	2014	601110.6	4044069	14.02	yes	13.96	-0.06
469	2014	601110.5	4044068	13.78	yes	13.96	0.18
470	2014	601110.4	4044068	13.69	yes	13.96	0.27
471	2014	601110.3	4044067	13.54	yes	13.61	0.07
472	2014	601110.1	4044066	13.35	yes	13.61	0.26
473	2014	601110.4	4044066	13.23	yes	13.61	0.38
474	2014	601109.7	4044064	13.12	yes	12.90	-0.23
475	2014	601109.5	4044063	13.02	yes	12.90	-0.13
476	2014	601109.4	4044063	12.97	yes	12.90	-0.08
477	2014	601109.3	4044062	12.86	yes	12.90	0.03
478	2014	601109.1	4044061	12.68	no	12.81	0.13
479	2014	601109	4044061	12.55	yes	12.35	-0.19
480	2014	601109	4044060	12.46	yes	12.35	-0.11
481	2014	601108.8	4044060	12.41	yes	12.35	-0.06
482	2014	601108.5	4044058	12.33	yes	12.35	0.02
483	2014	601108.3	4044058	12.30	yes	13.39	1.09
484	2014	601108.2	4044057	12.33	yes	13.39	1.07
485	2014	601108.1	4044055	12.28	yes	14.39	2.10
486	2014	601108	4044054	12.26	yes	14.39	2.13
487	2014	601107.9	4044054	12.24	yes	14.39	2.14
488	2014	601107.8	4044053	12.20	yes	14.39	2.18

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
489	2014	601107.1	4044050	12.28	yes	15.39	3.11
490	2014	601107	4044049	12.52	yes	15.39	2.87
491	2014	601106.8	4044048	13.17	yes	15.91	2.74
492	2014	601106.5	4044047	14.68	yes	15.91	1.23
493	2014	601106.4	4044047	15.50	yes	15.91	0.41
494	2014	601106.7	4044042	17.15	no	16.65	-0.50
495	2014	601113.4	4044084	14.25	no	14.31	0.06
496	2014	601070.2	4044097	13.30	yes	13.26	-0.04
497	2014	601070.2	4044097	12.90	yes	13.26	0.36
498	2014	601069.3	4044096	12.61	yes	12.78	0.17
499	2014	601068.6	4044095	12.53	yes	12.78	0.24
500	2014	601068.2	4044095	12.31	yes	12.40	0.09
501	2014	601067.8	4044094	12.11	yes	12.40	0.30
502	2014	601067.3	4044094	12.08	yes	12.40	0.33
503	2014	601066.7	4044093	12.18	yes	12.40	0.22
504	2014	601066	4044093	12.38	yes	12.48	0.09
505	2014	601065.3	4044092	12.49	yes	12.48	-0.01
506	2014	601065	4044092	12.51	yes	12.07	-0.43
507	2014	601064.2	4044091	12.29	yes	12.07	-0.21
508	2014	601063.5	4044091	11.93	yes	12.42	0.49
509	2014	601062.9	4044090	11.85	yes	12.42	0.57
510	2014	601062.3	4044089	11.81	yes	12.42	0.61
511	2014	601061.5	4044088	11.77	yes	12.40	0.64
512	2014	601060.8	4044088	11.71	yes	12.40	0.69
513	2014	601060.1	4044087	11.80	yes	12.84	1.03
514	2014	601059.4	4044087	11.89	yes	12.84	0.95
515	2014	601058.7	4044086	11.84	yes	12.84	0.99
516	2014	601058	4044085	11.82	no	14.20	2.38
517	2014	601057.4	4044084	11.88	yes	14.38	2.50
518	2014	601056.8	4044084	11.85	yes	14.38	2.53
519	2014	601056	4044084	12.03	yes	14.38	2.35
520	2014	601056	4044084	13.72	yes	14.38	0.65
521	2014	601070.3	4044097	12.98	no	13.26	0.28
522	2014	601009	4044146	11.76	no	12.09	0.33
523	2014	601070.3	4044097	13.00	no	13.26	0.26

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
524	2014	601092.7	4044080	14.17	no	14.10	-0.07
525	2014	601026.9	4044141	13.38	no	17.38	4.00
526	2014	601027.1	4044141	13.06	no	16.91	3.85
527	2014	601026.8	4044140	12.73	yes	16.53	3.81
528	2014	601026.4	4044140	12.44	yes	16.53	4.10
529	2014	601026.1	4044139	11.71	yes	16.53	4.82
530	2014	601025.9	4044139	11.22	yes	16.53	5.31
531	2014	601025.6	4044139	11.08	yes	16.53	5.46
532	2014	601025.5	4044138	11.12	yes	16.53	5.41
533	2014	601025.1	4044138	11.15	yes	16.53	5.38
534	2014	601024.4	4044137	11.15	no	15.43	4.28
535	2014	601023.8	4044136	11.17	yes	15.33	4.16
536	2014	601023.2	4044136	11.16	yes	15.33	4.17
537	2014	601022.6	4044135	11.13	yes	15.33	4.20
538	2014	601022	4044134	11.15	yes	14.23	3.08
539	2014	601021.4	4044134	11.17	yes	14.23	3.06
540	2014	601020.8	4044133	11.26	yes	13.42	2.16
541	2014	601020.2	4044132	11.29	yes	13.42	2.14
542	2014	601019.6	4044132	11.29	yes	13.42	2.13
543	2014	601019.2	4044131	11.33	yes	12.21	0.87
544	2014	601019.1	4044131	11.43	yes	12.21	0.78
545	2014	601018.7	4044130	11.53	yes	12.21	0.67
546	2014	601018.5	4044130	11.63	yes	12.21	0.58
547	2014	601018.2	4044130	11.83	yes	12.21	0.38
548	2014	601017.4	4044129	11.89	no	12.91	1.02
549	2014	601016.8	4044128	11.70	yes	14.10	2.40
550	2014	601016.3	4044128	11.73	yes	14.10	2.37
551	2014	601016	4044128	11.92	yes	14.10	2.18
552	2014	601015.8	4044127	12.44	yes	14.10	1.66
553	2014	601015.5	4044127	12.71	yes	14.10	1.39
554	2014	601015.3	4044127	12.86	yes	14.10	1.24
555	2014	601015.3	4044127	13.26	yes	14.10	0.84
556	2014	601026.9	4044141	13.24	no	17.38	4.14
557	2014	600959.6	4044185	11.65	no	12.48	0.84
558	2014	600983.9	4044187	14.15	yes	15.02	0.87

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
559	2014	600983.9	4044187	14.05	yes	15.02	0.97
560	2014	600983.4	4044187	13.82	yes	15.02	1.20
561	2014	600982.5	4044186	13.26	yes	13.17	-0.09
562	2014	600981.8	4044186	12.79	yes	13.17	0.38
563	2014	600981.4	4044185	12.42	yes	13.17	0.75
564	2014	600980.9	4044185	11.45	yes	13.82	2.37
565	2014	600980.4	4044184	11.26	yes	13.82	2.56
566	2014	600979.4	4044184	11.11	yes	13.82	2.71
567	2014	600979	4044183	11.14	no	13.72	2.58
568	2014	600978.2	4044182	11.17	yes	13.65	2.47
569	2014	600977.6	4044182	11.13	yes	13.65	2.51
570	2014	600977.1	4044181	10.95	yes	13.65	2.70
571	2014	600976.6	4044180	11.00	yes	12.74	1.74
572	2014	600975.9	4044179	11.04	yes	12.74	1.70
573	2014	600975.7	4044179	11.05	yes	12.74	1.69
574	2014	600975.2	4044178	11.09	yes	12.74	1.65
575	2014	600974.7	4044177	11.21	no	12.49	1.28
576	2014	600974.2	4044177	11.33	yes	11.63	0.31
577	2014	600973.6	4044176	11.17	yes	11.63	0.46
578	2014	600973.3	4044175	11.12	yes	11.63	0.52
579	2014	600972.8	4044175	11.16	yes	11.63	0.47
580	2014	600972.6	4044175	11.47	yes	11.63	0.16
581	2014	600972.1	4044174	12.05	yes	13.02	0.97
582	2014	600971.5	4044173	12.33	yes	13.02	0.69
583	2014	600971	4044173	12.58	yes	13.02	0.44
584	2014	600970.6	4044172	12.49	yes	13.02	0.53
585	2014	600970.4	4044171	12.48	yes	13.02	0.54
586	2014	600969.9	4044171	12.70	yes	13.64	0.94
587	2014	600969.6	4044170	12.69	yes	13.64	0.95
588	2014	600968.9	4044170	12.71	yes	14.27	1.56
589	2014	600969	4044170	13.28	yes	14.27	0.98
590	2014	600983.9	4044187	14.02	no	15.02	1.00
591	2014	600926.1	4044207	11.44	no	13.09	1.66
592	2014	600959.6	4044185	11.51	no	12.48	0.97
593	2014	600934	4044220	13.53	yes	16.15	2.62

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
594	2014	600934	4044220	13.39	yes	16.15	2.76
595	2014	600933.9	4044219	13.11	yes	16.15	3.04
596	2014	600933.6	4044218	12.91	yes	16.15	3.24
597	2014	600933.1	4044218	12.64	yes	16.15	3.51
598	2014	600932.7	4044217	12.32	no	15.22	2.90
599	2014	600932.3	4044216	12.03	yes	15.44	3.41
600	2014	600931.9	4044215	11.71	yes	15.44	3.73
601	2014	600931.7	4044214	11.42	yes	15.44	4.02
602	2014	600931.3	4044213	11.31	yes	13.92	2.61
603	2014	600930.9	4044213	11.12	yes	13.92	2.80
604	2014	600930.6	4044212	11.05	yes	13.92	2.87
605	2014	600930.3	4044211	10.96	yes	13.92	2.97
606	2014	600929.7	4044209	11.00	no	13.05	2.05
607	2014	600929.4	4044209	11.20	yes	13.79	2.59
608	2014	600929.1	4044208	11.24	yes	13.79	2.55
609	2014	600928.9	4044207	11.25	yes	13.02	1.76
610	2014	600928.3	4044205	11.27	yes	13.02	1.75
611	2014	600927.6	4044204	11.20	yes	12.00	0.80
612	2014	600927.5	4044203	10.99	yes	12.00	1.01
613	2014	600927.3	4044203	10.86	yes	12.00	1.14
614	2014	600927.2	4044202	10.83	yes	12.00	1.17
615	2014	600926.9	4044202	11.15	yes	12.00	0.85
616	2014	600926.6	4044202	11.77	no	11.91	0.14
617	2014	600926.3	4044201	11.99	yes	12.47	0.48
618	2014	600926.1	4044200	12.03	yes	12.47	0.45
619	2014	600925.7	4044199	12.11	yes	12.47	0.36
620	2014	600925.3	4044198	12.16	yes	12.84	0.68
621	2014	600925	4044197	12.37	yes	12.84	0.47
622	2014	600924.6	4044197	12.44	yes	12.84	0.40
623	2014	600924.6	4044197	12.66	yes	12.84	0.18
624	2014	600934.1	4044220	13.38	no	16.15	2.77
625	2014	600888.4	4044235	11.31	no	12.63	1.32
626	2014	600926.1	4044207	11.31	no	13.09	1.78
627	2014	600884.6	4044242	12.95	no	14.94	1.99
628	2014	600884.3	4044241	12.33	no	14.15	1.83

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
629	2014	600883.6	4044240	12.07	yes	14.36	2.29
630	2014	600883.2	4044239	11.66	yes	14.36	2.69
631	2014	600883.1	4044239	11.57	yes	14.36	2.78
632	2014	600882.8	4044238	11.21	yes	13.47	2.26
633	2014	600882.4	4044238	10.81	yes	13.47	2.66
634	2014	600882.3	4044237	10.64	yes	13.47	2.83
635	2014	600881.7	4044236	10.68	yes	13.47	2.79
636	2014	600881.4	4044235	10.68	yes	12.25	1.57
637	2014	600881	4044234	10.57	yes	12.25	1.67
638	2014	600880.6	4044233	10.49	yes	12.46	1.97
639	2014	600880.2	4044232	10.45	yes	12.46	2.01
640	2014	600879.8	4044232	10.42	yes	11.68	1.26
641	2014	600879.5	4044231	10.40	yes	11.68	1.28
642	2014	600879.1	4044230	10.35	yes	11.68	1.33
643	2014	600878.7	4044229	10.31	yes	12.83	2.51
644	2014	600878.3	4044228	10.36	yes	12.83	2.47
645	2014	600878	4044228	10.73	yes	12.83	2.10
646	2014	600877.6	4044227	10.77	yes	12.86	2.09
647	2014	600877.3	4044226	11.13	yes	12.86	1.74
648	2014	600877.2	4044226	11.55	yes	13.64	2.09
649	2014	600876.8	4044225	11.88	yes	13.64	1.77
650	2014	600876.5	4044224	12.23	yes	13.64	1.42
651	2014	600876	4044223	12.71	yes	13.64	0.93
652	2014	600876	4044223	12.90	yes	13.64	0.74
653	2013	597604.1	4043840	5.20	no	5.07	-0.13
654	2013	597602.8	4043826	4.51	no	3.74	-0.77
655	2013	597579.8	4043809	4.75	no	6.74	1.99
656	2013	597607.1	4043835	5.78	no	5.40	-0.38
657	2013	597629.7	4043817	4.04	no	4.98	0.94
658	2013	597565.7	4043834	3.41	no	3.22	-0.19
659	2013	597560.1	4043829	5.22	yes	4.46	-0.76
660	2013	597560.1	4043829	5.04	yes	4.46	-0.59
661	2013	597560.4	4043830	4.99	yes	4.46	-0.53
662	2013	597560.8	4043830	4.86	yes	4.09	-0.77
663	2013	597561	4043831	4.72	yes	4.09	-0.63

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
664	2013	597561.2	4043831	4.31	yes	4.09	-0.22
665	2013	597561.4	4043832	4.01	no	3.66	-0.35
666	2013	597562	4043834	3.77	yes	3.20	-0.57
667	2013	597562.1	4043834	3.44	yes	3.20	-0.23
668	2013	597562.2	4043834	3.32	yes	3.20	-0.12
669	2013	597562.6	4043835	3.32	yes	3.20	-0.12
670	2013	597562.9	4043836	3.26	yes	3.24	-0.02
671	2013	597563.2	4043837	3.23	yes	3.24	0.01
672	2013	597563.8	4043838	3.18	yes	3.24	0.06
673	2013	597564.1	4043839	3.18	no	3.44	0.25
674	2013	597564.6	4043840	3.12	yes	3.37	0.25
675	2013	597564.8	4043841	3.04	yes	3.37	0.32
676	2013	597565	4043842	2.91	yes	3.37	0.46
677	2013	597565.5	4043843	3.45	yes	4.10	0.65
678	2013	597565.8	4043844	3.90	yes	4.10	0.20
679	2013	597566.1	4043845	4.30	yes	4.10	-0.20
680	2013	597566.6	4043845	4.54	yes	4.94	0.40
681	2013	597566.9	4043846	4.92	yes	4.94	0.02
682	2013	597567.4	4043847	5.07	yes	4.94	-0.13
683	2013	597567.7	4043848	5.24	yes	5.45	0.21
684	2013	597568.2	4043850	5.47	yes	5.45	-0.02
685	2013	597568.4	4043851	5.46	yes	5.45	-0.01
686	2013	597560.1	4043829	5.81	no	4.46	-1.35
687	2013	597602.8	4043826	5.22	no	3.74	-1.48
688	2013	597633.4	4043815	4.52	yes	4.76	0.23
689	2013	597633.5	4043815	4.55	yes	4.76	0.21
690	2013	597633.4	4043816	4.46	yes	4.76	0.30
691	2013	597633.3	4043817	4.44	yes	4.76	0.32
692	2013	597633.1	4043818	4.33	yes	3.58	-0.76
693	2013	597632.9	4043819	3.96	yes	3.58	-0.39
694	2013	597632.8	4043820	3.77	yes	3.58	-0.19
695	2013	597632.6	4043820	3.35	yes	3.58	0.22
696	2013	597632.6	4043821	3.18	yes	3.24	0.06
697	2013	597632.5	4043822	3.11	yes	3.24	0.13
698	2013	597632.2	4043823	3.15	yes	3.24	0.09

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
699	2013	597632.1	4043824	3.17	yes	3.64	0.48
700	2013	597632.1	4043825	3.24	yes	3.64	0.40
701	2013	597632	4043825	3.31	yes	3.64	0.33
702	2013	597631.8	4043826	3.45	yes	3.64	0.19
703	2013	597631.5	4043827	3.65	no	3.98	0.32
704	2013	597631.5	4043828	4.06	yes	4.08	0.02
705	2013	597631.3	4043829	4.41	yes	4.08	-0.33
706	2013	597631.2	4043830	4.44	yes	4.74	0.30
707	2013	597631.1	4043831	4.37	yes	4.74	0.36
708	2013	597630.9	4043832	4.47	yes	4.74	0.26
709	2013	597630.6	4043833	4.63	yes	5.15	0.52
710	2013	597631	4043835	5.05	yes	5.15	0.10
711	2013	597631	4043835	5.46	yes	5.15	-0.31
712	2013	597633.4	4043815	5.96	no	4.76	-1.20
713	2013	597602.8	4043826	4.55	no	3.74	-0.81
714	2013	597633.4	4043815	4.51	no	4.76	0.25
715	2013	597678.4	4043834	4.51	no	3.76	-0.75
716	2013	597629.7	4043817	4.54	no	4.98	0.44
717	2013	597688.4	4043829	3.63	yes	5.73	2.10
718	2013	597687.8	4043829	5.31	yes	5.73	0.43
719	2013	597687.4	4043830	5.11	yes	5.32	0.21
720	2013	597687.3	4043830	4.90	yes	5.32	0.41
721	2013	597686.7	4043831	4.51	yes	5.32	0.81
722	2013	597686.4	4043832	3.98	yes	5.32	1.34
723	2013	597686.1	4043832	3.72	yes	5.06	1.34
724	2013	597685.6	4043832	3.35	yes	5.06	1.71
725	2013	597685.4	4043833	3.30	yes	5.06	1.76
726	2013	597685	4043834	3.32	yes	4.51	1.19
727	2013	597684.5	4043834	3.42	yes	4.51	1.09
728	2013	597684	4043835	3.45	yes	4.51	1.07
729	2013	597683.6	4043836	3.45	no	3.74	0.30
730	2013	597683.1	4043837	3.45	yes	3.29	-0.17
731	2013	597682.6	4043838	3.53	yes	3.29	-0.24
732	2013	597682.2	4043839	3.62	yes	3.95	0.34
733	2013	597681.7	4043840	3.77	yes	3.95	0.18

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
734	2013	597681.1	4043841	3.86	yes	3.95	0.09
735	2013	597681	4043841	4.02	yes	3.95	-0.06
736	2013	597680.6	4043841	4.17	yes	3.95	-0.22
737	2013	597679.8	4043842	4.33	yes	4.28	-0.05
738	2013	597679.4	4043843	4.64	yes	4.28	-0.36
739	2013	597679.3	4043843	4.87	yes	4.28	-0.59
740	2013	597688.4	4043829	4.97	no	5.73	0.76
741	2013	597729.5	4043866	5.30	no	3.97	-1.34
742	2013	597740.2	4043858	3.76	yes	4.72	0.96
743	2013	597740.1	4043858	5.64	yes	4.72	-0.91
744	2013	597739.9	4043859	5.24	yes	4.72	-0.52
745	2013	597739.6	4043860	5.32	yes	4.72	-0.60
746	2013	597739.3	4043860	5.26	yes	4.39	-0.86
747	2013	597738.9	4043861	5.01	yes	4.39	-0.62
748	2013	597738.1	4043862	4.84	yes	4.26	-0.58
749	2013	597737.7	4043862	4.23	yes	4.26	0.04
750	2013	597737.4	4043863	3.93	yes	4.26	0.33
751	2013	597736.8	4043863	3.97	yes	3.93	-0.04
752	2013	597736.1	4043864	3.81	yes	3.93	0.12
753	2013	597735.6	4043865	3.77	yes	3.93	0.16
754	2013	597735	4043866	3.73	no	3.83	0.10
755	2013	597734.6	4043867	3.68	yes	3.47	-0.21
756	2013	597734.1	4043868	3.75	yes	3.47	-0.28
757	2013	597733.6	4043869	3.75	yes	3.47	-0.27
758	2013	597733.1	4043869	3.74	yes	3.81	0.08
759	2013	597732.6	4043870	3.73	yes	3.81	0.08
760	2013	597732.4	4043870	3.75	yes	3.81	0.07
761	2013	597732	4043871	4.26	no	4.31	0.05
762	2013	597731.1	4043872	4.38	yes	4.58	0.20
763	2013	597731.1	4043872	4.62	yes	4.58	-0.05
764	2013	597740.2	4043858	4.73	no	4.72	0.00
765	2013	597752.2	4043877	5.63	no	3.32	-2.31
766	2013	597786.1	4043887	3.86	no	3.93	0.07
767	2013	597752.2	4043877	3.89	no	3.32	-0.57
768	2013	597793.9	4043875	3.87	no	8.01	4.14

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
769	2013	597793.6	4043876	6.07	yes	7.11	1.03
770	2013	597793.1	4043877	6.32	yes	7.11	0.79
771	2013	597792.6	4043878	6.06	no	5.93	-0.13
772	2013	597792.3	4043879	5.89	yes	5.03	-0.86
773	2013	597792	4043880	5.61	yes	5.03	-0.58
774	2013	597792	4043880	5.13	yes	5.03	-0.10
775	2013	597791.8	4043881	4.60	yes	5.03	0.43
776	2013	597791.8	4043882	3.71	yes	4.11	0.39
777	2013	597791.4	4043883	3.71	yes	4.11	0.40
778	2013	597791.2	4043884	3.71	yes	4.11	0.40
779	2013	597791.2	4043885	3.73	yes	3.44	-0.29
780	2013	597791	4043886	3.79	yes	3.44	-0.35
781	2013	597790.8	4043887	3.86	yes	3.44	-0.42
782	2013	597790.9	4043888	3.81	yes	4.50	0.68
783	2013	597790.8	4043889	3.72	yes	4.50	0.78
784	2013	597790.7	4043890	3.83	yes	4.50	0.66
785	2013	597790.8	4043891	3.94	yes	4.68	0.74
786	2013	597790.9	4043892	3.91	yes	4.68	0.77
787	2013	597790.6	4043893	4.06	yes	4.68	0.62
788	2013	597790.4	4043893	4.78	yes	4.68	-0.10
789	2013	597790.7	4043894	5.28	yes	4.99	-0.29
790	2013	597790.3	4043895	5.47	yes	4.99	-0.49
791	2013	597790.3	4043895	5.38	yes	4.99	-0.39
792	2013	597793.9	4043875	5.63	no	8.01	2.38
793	2013	597842.5	4043893	6.07	no	3.70	-2.36
794	2013	597786.1	4043887	3.98	no	3.93	-0.06
795	2013	597852.4	4043890	3.90	yes	6.34	2.44
796	2013	597852.5	4043890	5.44	yes	6.34	0.90
797	2013	597852.4	4043891	5.11	yes	6.34	1.23
798	2013	597852.4	4043891	4.72	yes	4.49	-0.23
799	2013	597852.2	4043892	4.49	yes	4.49	0.00
800	2013	597852.2	4043893	4.51	yes	4.49	-0.03
801	2013	597851.9	4043894	4.41	yes	4.49	0.08
802	2013	597851.8	4043894	3.70	yes	3.92	0.22
803	2013	597851.7	4043895	3.70	yes	3.92	0.23

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
804	2013	597851.8	4043896	3.93	yes	3.92	0.00
805	2013	597852.1	4043897	4.02	yes	3.89	-0.13
806	2013	597852	4043898	4.08	yes	3.89	-0.19
807	2013	597852	4043899	4.09	yes	3.89	-0.20
808	2013	597851.9	4043900	4.05	yes	4.38	0.33
809	2013	597851.8	4043901	3.99	yes	4.38	0.39
810	2013	597851.9	4043901	3.93	yes	4.38	0.45
811	2013	597851.9	4043902	4.31	yes	4.38	0.07
812	2013	597851.8	4043903	4.49	yes	4.38	-0.12
813	2013	597851.8	4043904	4.87	yes	4.82	-0.05
814	2013	597851.7	4043905	5.15	yes	4.82	-0.33
815	2013	597851.7	4043906	5.39	yes	4.82	-0.57
816	2013	597851.6	4043906	5.60	yes	4.82	-0.79
817	2013	597852.4	4043890	5.73	no	6.34	0.61
818	2013	597861.3	4043898	5.44	no	3.97	-1.47
819	2013	597837.7	4043891	4.10	no	3.52	-0.59
820	2014	615751.1	4033121	140.26	no	143.72	3.46
821	2014	615775.2	4033113	140.71	no	140.95	0.25
822	2014	615761.4	4033193	139.86	no	141.42	1.56
823	2014	615782.1	4033185	140.10	no	140.06	-0.04
824	2014	615785.3	4033247	137.65	no	141.32	3.67
825	2014	615803.5	4033239	139.30	no	139.39	0.09
826	2014	615812.7	4033307	138.53	no	144.51	5.98
827	2014	615831.9	4033295	138.13	no	139.30	1.17
828	2014	615846.1	4033361	138.11	no	139.61	1.50
829	2014	615860.8	4033353	135.32	no	138.30	2.97
830	2014	615878.5	4033403	137.24	no	139.71	2.47
831	2014	615891.9	4033389	137.28	no	137.42	0.14
832	2013	615480	4032134	164.38	no	164.87	0.49
833	2013	615481.4	4032137	164.02	no	165.03	1.01
834	2013	615483.2	4032141	163.93	no	164.22	0.29
835	2013	615484.8	4032143	163.82	no	164.20	0.38
836	2013	615485.6	4032145	163.85	yes	164.17	0.33
837	2013	615486.1	4032146	163.64	yes	164.17	0.53
838	2013	615487.7	4032150	163.54	yes	164.15	0.61

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
839	2013	615488.1	4032152	163.45	yes	164.15	0.70
840	2013	615488.6	4032154	163.39	yes	164.85	1.45
841	2013	615489.7	4032155	163.38	yes	164.85	1.47
842	2013	615490.5	4032157	163.22	yes	165.16	1.94
843	2013	615490.9	4032158	163.09	yes	165.16	2.07
844	2013	615491.1	4032159	162.95	yes	166.25	3.30
845	2013	615491.4	4032160	162.94	yes	166.25	3.31
846	2013	615491.5	4032161	162.98	yes	166.25	3.27
847	2013	615491.5	4032161	163.11	yes	166.25	3.14
848	2013	615492	4032162	163.70	no	167.32	3.62
849	2013	615492.9	4032165	163.73	no	166.60	2.87
850	2013	615493	4032166	163.83	yes	167.68	3.85
851	2013	615493.9	4032167	163.83	yes	167.68	3.85
852	2013	615494.6	4032169	163.33	yes	168.75	5.42
853	2013	615495	4032170	163.04	yes	168.75	5.71
854	2013	615495.6	4032171	162.93	yes	169.80	6.87
855	2013	615495.2	4032173	163.05	yes	169.80	6.75
856	2013	615495.5	4032173	163.63	yes	169.80	6.17
857	2013	615451.2	4032138	164.65	no	165.00	0.35
858	2013	615451.1	4032139	164.67	yes	164.74	0.08
859	2013	615451.1	4032140	164.29	yes	164.74	0.45
860	2013	615451	4032141	163.96	yes	164.13	0.16
861	2013	615451.2	4032143	163.79	yes	164.13	0.33
862	2013	615451.6	4032144	163.68	yes	164.15	0.47
863	2013	615452.1	4032146	163.77	yes	164.15	0.38
864	2013	615452.4	4032148	163.78	yes	164.09	0.30
865	2013	615452.6	4032149	163.62	yes	164.09	0.47
866	2013	615453.1	4032150	163.77	no	163.95	0.18
867	2013	615453.4	4032152	163.77	no	163.83	0.06
868	2013	615453.7	4032153	163.66	yes	163.69	0.04
869	2013	615453.9	4032154	163.42	yes	163.69	0.28
870	2013	615454.1	4032155	163.42	yes	163.69	0.27
871	2013	615454.3	4032156	163.31	yes	163.69	0.38
872	2013	615454.8	4032157	163.28	no	163.55	0.27
873	2013	615455.2	4032159	163.36	yes	163.41	0.05

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
874	2013	615455.7	4032161	163.17	yes	163.41	0.25
875	2013	615455.9	4032162	163.11	no	163.34	0.23
876	2013	615456.4	4032164	162.90	no	163.46	0.56
877	2013	615456.8	4032166	162.83	yes	164.55	1.72
878	2013	615457	4032167	162.75	yes	164.55	1.80
879	2013	615457.2	4032167	162.64	yes	164.55	1.91
880	2013	615457.3	4032168	162.59	yes	164.55	1.95
881	2013	615457.4	4032168	162.56	yes	165.64	3.07
882	2013	615457.5	4032169	162.71	yes	165.64	2.93
883	2013	615457.7	4032169	162.76	yes	165.64	2.88
884	2013	615457.7	4032169	162.87	yes	165.64	2.77
885	2013	615457.9	4032170	162.86	yes	165.64	2.78
886	2013	615458.1	4032171	163.33	yes	166.73	3.39
887	2013	615458.5	4032173	163.10	yes	166.73	3.62
888	2013	615458.9	4032174	163.07	yes	166.73	3.66
889	2013	615459.3	4032175	163.22	no	167.76	4.55
890	2013	615459.4	4032176	163.24	yes	167.98	4.74
891	2013	615459.6	4032177	163.14	yes	167.98	4.84
892	2013	615451.8	4032138	164.66	no	165.00	0.34
893	2013	615451.3	4032139	164.68	yes	164.74	0.07
894	2013	615450.6	4032140	164.29	yes	164.74	0.45
895	2013	615449.9	4032140	164.01	no	164.62	0.60
896	2013	615448.2	4032141	163.89	no	164.05	0.16
897	2013	615446.4	4032143	163.80	no	164.07	0.27
898	2013	615444.8	4032144	163.75	no	164.15	0.40
899	2013	615442.8	4032147	163.97	no	164.12	0.14
900	2013	615441.7	4032148	163.58	no	164.33	0.75
901	2013	615440	4032150	163.47	no	164.01	0.54
902	2013	615437.9	4032152	163.41	yes	163.80	0.40
903	2013	615436.9	4032153	163.52	yes	163.80	0.28
904	2013	615435.7	4032153	163.27	no	163.62	0.34
905	2013	615434.5	4032154	162.89	yes	163.42	0.53
906	2013	615434.1	4032155	162.66	yes	163.42	0.76
907	2013	615433.8	4032155	162.44	yes	163.42	0.98
908	2013	615433.2	4032155	161.98	yes	163.42	1.44

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
909	2013	615431.9	4032156	161.82	no	163.22	1.40
910	2013	615431.3	4032157	162.06	yes	163.03	0.97
911	2013	615430.8	4032158	162.04	yes	163.03	0.99
912	2013	615430.1	4032159	161.77	yes	163.03	1.26
913	2013	615429.2	4032159	161.56	no	162.92	1.36
914	2013	615428.3	4032160	161.43	yes	164.24	2.81
915	2013	615427.3	4032161	161.43	yes	164.24	2.81
916	2013	615426.4	4032162	161.26	yes	164.24	2.98
917	2013	615425.9	4032162	161.09	no	165.70	4.61
918	2013	615425.6	4032162	162.34	yes	167.03	4.69
919	2013	615425.5	4032162	162.46	yes	167.03	4.57
920	2013	615425.2	4032163	162.72	yes	167.03	4.31
921	2013	615424.7	4032163	162.93	yes	167.03	4.10
922	2013	615424.5	4032164	163.04	yes	167.03	3.98
923	2013	615411.4	4032113	164.25	no	164.50	0.25
924	2013	615407	4032118	163.57	yes	163.56	-0.01
925	2013	615405.5	4032119	162.72	yes	163.56	0.84
926	2013	615404.8	4032119	162.48	no	163.24	0.76
927	2013	615403.9	4032121	162.42	yes	163.00	0.58
928	2013	615403.2	4032122	162.34	yes	163.00	0.65
929	2013	615402.6	4032123	162.19	yes	162.81	0.62
930	2013	615402.2	4032123	162.13	yes	162.81	0.68
931	2013	615401.9	4032124	162.19	yes	162.81	0.62
932	2013	615401.6	4032124	162.18	yes	162.81	0.63
933	2013	615401.5	4032125	162.32	yes	162.81	0.49
934	2013	615401.4	4032125	162.53	yes	162.70	0.17
935	2013	615401	4032125	162.71	yes	162.70	-0.01
936	2013	615400.5	4032126	162.83	yes	162.66	-0.17
937	2013	615400.1	4032126	162.73	yes	162.66	-0.07
938	2013	615399.5	4032127	162.76	yes	162.66	-0.10
939	2013	615398.7	4032127	162.83	yes	162.66	-0.17
940	2013	615398.5	4032128	162.62	yes	162.66	0.04
941	2013	615397.7	4032129	162.39	yes	163.36	0.97
942	2013	615397.1	4032129	162.38	yes	163.36	0.98
943	2013	615396.8	4032129	162.47	yes	163.36	0.90

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
944	2013	615396.1	4032130	162.88	yes	163.36	0.49
945	2013	615395.9	4032130	163.10	yes	163.36	0.27
946	2013	615395.1	4032132	163.03	yes	163.31	0.29
947	2013	615393.7	4032133	163.09	yes	163.31	0.23
948	2013	615393.4	4032133	163.18	yes	163.31	0.13
949	2013	615393	4032134	163.42	yes	163.31	-0.11
950	2013	615391.9	4032135	163.31	yes	163.56	0.24
951	2013	615391.1	4032136	163.45	yes	163.56	0.11
952	2013	615388.8	4032138	163.75	no	163.95	0.20
953	2014	615408.3	4032116	163.98	no	163.82	-0.16
954	2013	615332	4032110	163.34	no	163.54	0.20
955	2013	615332.5	4032111	163.05	yes	163.27	0.23
956	2013	615333.1	4032112	162.72	yes	163.27	0.55
957	2013	615333.8	4032114	162.16	yes	162.73	0.57
958	2013	615334.1	4032115	161.85	yes	162.73	0.88
959	2013	615334.4	4032116	161.78	no	162.60	0.81
960	2013	615334.5	4032118	161.81	yes	162.32	0.50
961	2013	615334.7	4032119	161.79	yes	162.32	0.53
962	2013	615334.8	4032120	161.80	yes	162.55	0.75
963	2013	615336	4032120	161.89	yes	162.55	0.66
964	2013	615336.8	4032122	162.04	yes	162.55	0.51
965	2013	615337.2	4032123	162.33	no	163.55	1.22
966	2013	615337.8	4032124	162.98	no	163.78	0.80
967	2013	615300	4032155	162.83	yes	162.59	-0.24
968	2013	615298.4	4032155	162.71	yes	162.59	-0.12
969	2013	615296.1	4032156	162.59	no	162.30	-0.28
970	2013	615294.4	4032156	162.07	yes	162.71	0.64
971	2013	615293.6	4032156	161.85	yes	162.71	0.85
972	2013	615292.7	4032156	161.66	yes	162.71	1.05
973	2013	615291.4	4032156	161.37	yes	163.67	2.30
974	2013	615289.7	4032157	161.12	yes	163.67	2.55
975	2013	615288.2	4032157	161.04	yes	164.65	3.61
976	2013	615286.8	4032158	161.03	yes	164.65	3.63
977	2013	615285.3	4032158	160.91	yes	165.64	4.73
978	2013	615283.7	4032158	160.82	yes	165.64	4.82

Point ID	Year	Easting	Northing	Total Station Elevation (m)	Averaged	LiDAR Elevation (m)	Elevation Difference (LiDAR - Total Station) (m)
979	2013	615282.2	4032159	160.46	yes	166.64	6.18
980	2013	615281.7	4032159	160.33	yes	166.64	6.30
981	2013	615281.6	4032159	160.63	yes	166.64	6.01
982	2013	615281.3	4032159	161.66	yes	166.64	4.98
983	2013	615281.1	4032160	162.69	yes	166.64	3.95

8 Appendix B – Data Analysis & R Code

```
data=read.csv(file.choose())
lidar=data$LIDAR_ELEV
elev=data$ELEVATION_
RMSE=sqrt((sum((lidar-elev)^2)/length(lidar)))
hist(lidar-elev, main = "Historgram of Residuals", xlab= "Residuals")
mean= mean(lidar-elev)
sd=sd(lidar-elev)
shapiro.test(lidar-elev)

#############  MSE   ############
n=length(lidar)
mse=(sum((lidar-elev)^2))/(n)

############ sd mse #################
sdx2=sqrt((sum(((lidar-elev)^2-mse)^2))/(n))
sdmse=(sdx2/sqrt(n))

############ skew  ##################
skew= ((n*(sum(((lidar-elev)^2-mse)^3))))/((n-1)*(n-2)*(sdx2^3))
skew_mse=(skew/(sqrt(n)))

############# kurtosis ################
kurt=(((n*(n+1))*(sum(((lidar-elev)^2-mse)^4)))/((n-1)*(n-2)*(n-3)*(sdx2^4)))-
               ((3*(n-1)^2)/((n-2)*(n-3)))
kurt_mse= (kurt/n)

############ rmse #####################
t=0.95
rmse_upper=sqrt(mse + ((((kurt_mse + 2)/skew_mse) +  sqrt((((kurt_mse + 2)/skew_mse)^2) +
                         4 * ((t*sqrt((kurt_mse+2)*(kurt_mse+2-(skew_mse^2)))/
                                      (abs(skew_mse)))+1)))/2) * sdmse)
rmse_lower=sqrt(mse + ((((kurt_mse + 2)/skew_mse) - sqrt((((kurt_mse + 2)/skew_mse)^2) +
                         4 * ((t*sqrt((kurt_mse+2)*(kurt_mse+2-(skew_mse^2)))/
                                      (abs(skew_mse)))+1)))/2) * sdmse)

############ CI For Mean ###########

############## Skew Mean #############
xi=lidar-elev
skew_2= ((n*(sum((xi-mean)^3)))/((n-1)*(n-2)*(sd^3)))
skew_mean=(skew_2/(sqrt(n)))

############### kurtosis mean ############

kurt_2= ((n*(n+1)*sum((xi-mean)^4))/((n-1)*(n-2)*(n-3)*(sd^4)))-
 ((3*((n-1)^2))/((n-2)*(n-3)))
kurt_mean= kurt_2/n

############## Mean CI ###############
mu_upper= (mean + (((kurt_mean +2)/skew_mean) + (sqrt((((kurt_mean +2)/skew_mean)^2)
                    + 4 * ( ( (t * (sqrt( (kurt_mean +2) * (kurt_mean +2 - (skew_mean^2)
) )
                              ) ) / (abs(skew_mean)) ) +1 ))) / 2 ) * (sd/sqrt(n)) )
mu_lower= (mean + (((kurt_mean +2)/skew_mean) - (sqrt((((kurt_mean +2)/skew_mean)^2)
                   + 4 * ( ( (t * (sqrt( (kurt_mean +2) * (kurt_mean +2 - (skew_mean^2) )
) )
                              ) / (abs(skew_mean)) ) +1 )  )) / 2 ) * (sd/sqrt(n)) )

############### Vertical Error ##################
x_upper= mu_upper + t*sd
x_lower=mu_lower - t*sd
```